NATIONAL TRANSPORTATION SAFETY BOARD

THE INVESTIGATION OF KOREAN AIR FLIGHT 801, B-747-300, AGANA, GUAM AUGUST 6, 1997

Ballroom A and B
Hawaii Convention Center
1833 Kalakaua Avenue
Honolulu, Hawaii 96815

Thursday, March 26th, 1989
8:00 a.m.

NTSB Board of Inquiry Members

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BEN BERMAN
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A G E N D A

P R O C E E D I N G S

8:00 a.m.

CHAIRMAN FRANCIS: Mr. Feith's watch indicates that it's now 8:00. So, I think we'll get started, and hopefully with an eye on making certain that we do our usual comprehensive job. If we can move along, maybe we won't still be here at late in the day this afternoon.

Our first witness is Nelson Spohnheimer, National Resource Engineer for Navigation at the FAA in Renton, Washington.

Whereupon,

NELSON SPOHNHEIMER

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

TESTIMONY OF NELSON SPOHNHEIMER
NATIONAL RESOURCE ENGINEER FOR NAVIGATION
FEDERAL AVIATION ADMINISTRATION
RENTON, WASHINGTON

MR. SCHLEEDE: Please give us your full name and business address for the record.

THE WITNESS: Yes. Good morning. My name is Levi Nelson Spohnheimer. I work for the FAA at the

Northwest Mountain Region Headquarters in Seattle, 1601 Lind Avenue, SW, Renton, Washington 98055.

MR. SCHLEEDE: Thank you. And what is your position at the FAA?

THE WITNESS: Well, my title is National Resource Engineer for Navigation, which -- which means that I work on a wide variety of technical topics related to all kinds of ground-based navigational aids and their flight testing.

MR. SCHLEEDE: Would you give us a brief summary of your education, training and experience that qualifies you for this position?

THE WITNESS: Surely. I have an electrical engineering degree from Iowa State University. I worked for about six years in industry for Texas Instruments and Motorola as a radio frequency design engineer. During that time, I became system engineer on an instrument landing systems contract, and as a result, I joined the FAA. I've been working on ground-based nav aids of all types for about 24 years.

MR. SCHLEEDE: Thank you very much.

Mr. Phillips will proceed.

MR. PHILLIPS: Good morning, Mr. Spohnheimer.

THE WITNESS: Good morning.

MR. PHILLIPS: Have you had any accident investigation experience in your career?

THE WITNESS: Well, yes, I have. I'm -- I'm the Northwest Mountain Region accident representative for airway facilities, and I work on various national accidents, typically those having navigation issues.

I've worked on the litigation of a number of cases, and I've served on the Air Force Board for the Bosnia accident.

MR. PHILLIPS: Okay. Most of your experience then has dealt with the ground-based side of the equipment?

THE WITNESS: In general, that's correct. I -- I spent a lot of time with the airborne flight testing organization, but most of my work is on the ground equipment.

MR. PHILLIPS: Could you describe a typical work day for yourself?

THE WITNESS: Well, fortunately, it varies quite a lot. I travel extensively, about 40 weeks a year. So, each week is different. But in a given month or two period, I might teach a technical class or seminar, do some trouble-shooting work on signal and space problems with ground-based nav aids, visit two or three companies who have applied for FAA approval for their nav aids equipment, write some technical papers.

I serve on a couple international civil aviation organization committees that deal with standards and testing of ground-based nav aids.

MR. PHILLIPS: Okay. Have you been present the last two days during the testimony in the hearing, and are you familiar with the issues in this hearing?

THE WITNESS: Yes, I have, and I am.

MR. PHILLIPS: Okay. And specifically, I realize that your expertise covers a lot of areas, I'd like to address my questioning today in the areas of the instrument landing systems, and along those lines, I'd like to ask you just a few questions about what is an ILS. Let's lay a little foundation for what is an instrument landing system, how does it work. Go ahead.

THE WITNESS: Okay. An instrument landing system is a ground-based electronics system composed of about six subsystems that provide lateral and vertical guidance and fixes or rough knowledge of position to the pilot along the approach path to an airport.

MR. PHILLIPS: Would you -- would we like to go ahead and put up Page 6 of Exhibit 9-E, Teddy? Would this help in your discussion?

THE WITNESS: Well, yes, thank you. This is the simplified but sufficient diagram of the nature of the needle indications that are provided to a pilot while flying an instrument landing system approach.

The needle, as you can see in the bottom right-hand corner of the -- of the picture or the indicator, rather, consists of two needles, a fly right/fly left and a fly up/fly down, and the antenna system on the ground is arranged in such a way that these needles deflect proportionately more and more as the aircraft departs more and more from the desired course or glide path.

The system operates by transmitting two tones, much like two notes on the piano, and these tones are arranged to be equal in signal strength on the desired path, and -- and as the airplane moves from the desired path, the two tones become unequal in magnitude, and -- and it is that inequality that moves the needles on the cockpit indicator.

MR. PHILLIPS: Is this -- is this the standard ILS system used around the world? Are there any differences in the design?

THE WITNESS: No. This -- this basic character is -- has been standardized worldwide for nearly 50 years.

MR. PHILLIPS: Okay. Speaking of standards, are there technical standards that dictate the design requirements for ILS components?

THE WITNESS: Yes, there are a number. Internationally, the signal and space is defined by the International Civil Aviation Organization in a document called "Annex 10". The standards -- the standards are listed in the manner that define very fully the signal and space characteristics.

Receivers, which must use that signal and space, have their characteristics defined by, in general, two organizations, RTCA in the U.S., which is the Radio Technical Commission for Aeronautics, and a European equivalent called Eurocae, E-U-R-O-C-A-E. These bodies are -- are consortiums of manufacturers in general and regulatory agencies, and their standards define how the receiver will react to the signal and space that's defined by ICAO.

MR. PHILLIPS: Okay. Do the FAA requirements require these standards to be met before they're installed on airplane or ground-based equipment?

THE WITNESS: Yes. For -- for most operations, certainly air carrier operations, the -- the receivers must meet what's called a technical standard order, a TSO, which FAA publishes. It provides a regulatory trail to the RTCA standards in most cases. So that an approved installation on an airplane of an instrument landing system receiver must meet the applicable RTCA document.

MR. PHILLIPS: How long have instrument landing systems been in use?

THE WITNESS: Difficult to say precisely, but the early development occurred roughly at the beginning of World War II, and the system that we know today was pretty well standardized by the end of World War II.

MR. PHILLIPS: Okay. Have there been enhancements or improvements over the years into that system?

THE WITNESS: Well, yes, on the ground side. Although the basic signal generation system has been pretty much standard, the antenna systems that attempt to keep the signal of high quality, straight, with no variations along the approach path, have had to get more and more advanced due to the encroachment of hangars and other reflecting sources on or near airports.

So, in -- in the main, the science of instrument landing systems is the science of antenna systems on the ground side.

On the airborne side, of course, as we went from tubes to transistors to integrated circuits and now software-based or receivers that contain software, there's a continual advancement in the performance, but the general description and the general way in which all ground and airborne systems behave has remained unchanged.

MR. PHILLIPS: In regards to some of the RTCA standards that control the design or specify the design for this equipment, specifically DO-131, 132, 192 and 195, can you elaborate on -- on your opinion or assessment of the differences in these standards over the years?

THE WITNESS: Surely. Two ofhtose were published in 1978 and defined how localizer and glide scope receivers should behave, and the other two were published in the mid-'80s, I think 1986, and were updates to address the changing environment in which aircraft operate.

For example, the occasion of other transmitters, paging systems, cellular radio systems, tv systems and so on has meant that receivers have to be able to operate in more and more demanding environments. As these installations encroach around airports, the frequency congestion gets higher.

So, one of the areas about receiver design that has received a lot of attention in the last four or five years is increased immunity to such out-of-band signals, and, of course, the software is a new -- relatively new change in airborne equipment, and one of the more recent updates deals with software quality assurance.

MR. PHILLIPS: Okay. Are you aware of any accidents or incidents where ILS system components, ground-based side, because of your experience, have been an issue?

THE WITNESS: No, I'm not. I have worked on a number of lawsuit cases as a witness, and to my knowledge, no instrument landing system has been found causative for an accident.

MR. PHILLIPS: You heard the testimony, I believe, in the beginning day of the hearing, the crew of Korean Air Flight 801 commented several times about a glide scope signal or at least the glide scope flag, glide scope operation, when the -- we know -- we know that the glide scope equipment wasn't present at the time, the transmitter.

Would you like to comment on that in general terms?

THE WITNESS: Well, yes. As you say, the -- the intended glide scope signal had been removed for service to replace its shelter and was out of service for about a month prior to and after the accident.

The pilot would normally be warned that a signal is not present by the presence of a flag, a warning flag, that indicates that something about the receiver system or something about the ground system is abnormal, and one has to assume that these remarks had to do with the presence or absence of flags.

There are enough remarks in the record that I have to conclude that there must have been some sort of flag activity coming into view, disappearing from view, some time during the approach.

MR. PHILLIPS: Is that unusual in lieu of the fact that we know no transmitter was present?

THE WITNESS: Well, no. When we have an empty channel, many of these potential external sources of noise and unintended signals, which are normally too weak to be heard, can be heard, and it's fairly common when we test airborne flight tests, instrument landing systems, and we turn off the localizer or the glide scope that -- that we record on our instrumentation intermittent indications of flag and needle activity, and as a result, the aviation community relies on notices to airmen as a procedural means to advise everyone that the channel is empty.

MR. PHILLIPS: Would you expect these -- this flag movement to cover a time period that would indicate to a crew that the signal may be valid?

THE WITNESS: Well, no. The typical case of finding some sort of activity on instrumentation is very short duration, intermittent, and -- and pilots usually refer to these brief movements of the flag as flag pops.

For a crew or a pilot to conclude that a signal is on the air and flyable would probably require the flag to remain in a static condition for 10 or more seconds perhaps.

MR. PHILLIPS: Is there any indication in your mind in the transcript, the CVR transcript, to indicate that the length of time these flags may or may not have been in view?

THE WITNESS: Well, the -- the individual comments, of course, do not convey much information about the duration of any flag activity, but I would conclude that there must have been enough absence of flag for the crew to occasionally decide that the system was on the air when in fact it wasn't.

MR. PHILLIPS: If the flag moved out of view, would you have expected to see a needle deflection of any sort, a fly-up or fly-down positional command?

THE WITNESS: Well, on an empty channel, that's very statistically hard to determine. The nature of the various interference or noises, electrical noises, that might cause the flag to move is pretty random, and, so, some of those will cause a quick deflection of the needle, returning it to zero. Others might deflect a needle for a short time. It is quite random in the general case.

We have many recordings from our flight test organization that shows what most people would call erratic needle movement.

MR. PHILLIPS: Can you elaborate a little on the flight test of an ILS system? What's done, and the frequency, and --

THE WITNESS: Yes. In the U.S., instrument landing systems are flight-inspected on a periodic basis. The -- the period ranges from a few months to about 10 months at the maximum.

During each of these flight tests, the alignment of the localizer and the glide path, the amount of needle deflections when the aircraft is off the path, and the actions of the ground-based monitoring system that removes the signal from service when it exceeds certain standards, are all tested and recordings are made. Every other flight inspection is a brief one, might take 30 to 45 minutes. The alternative flight inspections typically take several hours.

MR. PHILLIPS: These flight inspections are conducted with specially-instrumented aircraft or ground-based or --

THE WITNESS: That's correct. I'm speaking about the airborne testing. The aircraft are equipped with quite a lot of unusual avionics and recording capability that provide engineering quality measurements of the signal characteristics.

MR. PHILLIPS: Okay. Could you address flight testing at the Guam Airport; specifically, the post-accident testing that may have been conducted on the system?

THE WITNESS: Yes. We -- we, of course, have a policy that after accidents, any ground-based navigational aids that may have been involved are -- are flight tested as quickly as feasible after the accident, and, so, of course, there was a flight test of those components of the ILS that were in service at the time of the accident, and everything was found normal.

MR. PHILLIPS: Okay. Back to an earlier discussion of the ILS system, we didn't talk about the marker beacons. Would you give us a general description of what a marker beacon is, and what it is to an instrument approach?

THE WITNESS: Surely. A marker beacon is a small and fairly simple ground-based transmitter system that transmits an upward-directed antenna pattern through which the airplane flies on the approach. It causes a separate receiver in the aircraft to light a particular light, different-colored lights, for the different markers that are usually installed on an approach.

The outer marker, inner marker, and middle marker would be the full complement for a high-precision landing system. Each one has a separate light on the instrument panel. So, for about five to 15 seconds, as the aircraft flies through the antenna pattern of each marker station, the associated light will illuminate.

MR. PHILLIPS: Testing of the marker beacons is a part of the flight check?

THE WITNESS: That's correct. The -- the lineal distance along the flight path, the time for which the light is illuminated, is tested and set to a specific value.

MR. PHILLIPS: Is there anything to alert the ground control tower or ATC specialist that a marker beacon system is inoperative?

THE WITNESS: That varies with the installation. In the general case, in the U.S., we do remotely monitor the status, on-air/off-air status of -- of all the components of an instrument landing system.

Certainly for Category 2 and Category 3 higher-precision systems, that is a requirement. For Category 1 systems, such as at Guam, it's not uncommon for the outer marker and sometimes the middle marker to not have remote monitoring because the absence of -- because of the absence of communications lines, phone lines, being available to remote this indication to air traffic control.

So, at Guam, the outer marker is not monitored. The remote status is not monitored.

MR. PHILLIPS: Would -- would you consider an inoperative marker beacon -- would the ILS be operational with an inoperative marker beacon?

THE WITNESS: Yes, in most all cases. It depends upon the design of the instrument approach procedure, but in the general case, the outer marker absence can be substituted with DME or radar vectoring or a compass locator.

So, it's fairly uncommon that the absence of the outer marker eliminates an instrument approach, an

ILS approach.

MR. PHILLIPS: Okay. Backtracking just a little bit on your comments about flag pops, do you -- in your view, in your opinion, do you believe that there's -- there's appropriate FAA guidance regarding flag movement on empty channels, I guess specifically in regards to the airman's information manual and flight training practices?

THE WITNESS: Well, I think so. The -- the airman information manual, of course, describes the situation of navigational aids that are off the air. For example, in the U.S., we have perhaps in round numbers 100 instrument landing system approaches which are based on a localizer-only installation. No glide scope has ever been installed.

So, it is common that pilots have to deal with either a glide scope that's been installed being temporarily out of service, or a glide scope that was never installed presenting an empty channel to every -- every airplane on approach, and therefore the aviation community again, as I said earlier, relies on procedural methods, such as notices to airmen and ATIS announcements, to advise pilots that -- that a particular navigational aid is out of service.

MR. PHILLIPS: If a crew was advised that the glide scope was unusable, do you believe that there's any duration of signal long enough to decide that the approach to the glide scope would be flyable?

THE WITNESS: I'm sorry. Would you perhaps restate that?

MR. PHILLIPS: In your understanding of -- of the instructions to the flight crews in the airmen's information manual, is there any period of time -- if -- if the approach was -- the glide scope was inoperative or unusable, would there be any duration of flag out of view that would be considered enough to consider the -- the source valid?

THE WITNESS: I guess I'll have to assume that you mean if there's a -- if it's announced that the system is --

MR. PHILLIPS: Yes.

THE WITNESS: -- unusable?

MR. PHILLIPS: Yes.

THE WITNESS: Well, if it's announced, and a notice to airmen has been issued, then I think it's quite clear that no period of flag activity, present or absent, warrants use of the navigation signal.

One reason this must be the case is that even though a glide scope or a localizer may be radiating during periods of ground maintenance, we're required to issue a notice to airmen, and during a period that may last for several hours, the system may radiate signals that appear normal, signals that may be flawed.

The various sorts of testing that must be done on a routine basis for ground maintenance result in signals which, from the pilot's point of view, may appear to be valid. A flag would be out of view. A needle would be deflecting in either normal or abnormal methods or manners, however, and therefore the -- the procedural method of advising the pilot not to use the indications is -- is critical.

CHAIRMAN FRANCIS: Greg, could I interject a question here?

MR. PHILLIPS: Sure.

CHAIRMAN FRANCIS: In a situation where you have a glide scope, a fully-operative ILS system, I assume that the glide scope is subjected to remote maintenance monitoring of some sort that you've got the --

THE WITNESS: That's correct. I think you're perhaps referring to what we call integrity monitoring.

CHAIRMAN FRANCIS: I'm dated.

THE WITNESS: There are -- there are three types of monitoring. One is physically present at the transmitter site, and that integrity monitor will turn the transmitter off any time the signals exceed the international standards.

CHAIRMAN FRANCIS: And when that happens, how does the FAA deal with notification of the pilot community?

THE WITNESS: Well, we issue a NOTAM, a notice to airmen, as soon as we're aware that the system is off the air.

CHAIRMAN FRANCIS: And then ATIS and ATC will --

THE WITNESS: That's correct. Depending on the airport, within a short time, -- well, air traffic control will verbally announce to every arriving pilot until such time as the NOTAM or the ATIS recording has been made accurate.

CHAIRMAN FRANCIS: I think that Mr. Phillips' questioning on this, how do you -- how do you make certain that pilots are sensitive to the fact that when they're getting the NOTAM, the controller clearance or whatever it is, that they must ignore any flag activity in the cockpit is -- is one that it certainly would be interesting for the FAA and the international community to pursue, how in training, in the AIM or wherever it is, that -- that we -- we emphasize that enough so that you at least minimize the distraction factor.

THE WITNESS: Certainly. The airmen's information manual and -- and ground school in the general case addresses these issues, although I don't have any oversight knowledge about how -- how thorough that is.

CHAIRMAN FRANCIS: Okay.

MR. PHILLIPS: As part of this flight testing and ground testing of the equipment, are the FAA technicians who perform these tests and review them specially trained or certified?

THE WITNESS: Yes. The ground technicians who maintain an instrument landing system must earn certification credentials by attending a theory class or -- or taking a bypass examination, receiving some on-the-job training, and demonstrating proficiency in a performance examination administered by someone who is already certified, and once the credentials are earned and an assignment to maintain a facility is made, then the national ILS maintenance handbook defines the types of tests, the periods for the tests, the frequency, in general provides the guidance necessary for the technician to periodically test and make a judgment that the system is safe to leave in operation.

MR. PHILLIPS: I'd like to go back to the area of needle movements and flag pops and the potential for those kinds of activities.

Can you describe some of the signals that would potentially cause the flag to move or the needle to deflect, the source of the signal?

THE WITNESS: Okay. Certainly. I mentioned that the -- that the ILS operates by transmitting two tones, and the difference in the signal strength of those tones is what deflects the, in the case of a glide scope, the fly-up and fly-down needle.

So, that means that the receiver has some circuits in it which are looking for those two particular tones, filters that --

MR. PHILLIPS: Would this be a good point to put up Exhibit 9-G?

THE WITNESS: Perhaps, --

MR. PHILLIPS: This was --

THE WITNESS: -- if that's the --

MR. PHILLIPS: Yeah. That's the --

THE WITNESS: -- diagram.

MR. PHILLIPS: -- schematic. For the benefit of the tables, this exhibit was added this morning. It's a one-page aid.

THE WITNESS: Yes. This is a diagram of -- at the most basic level of an ILS receiver on the top half of the -- of the view there.

The filters in the top center labeled 90 and 150 are those filters that are looking for these two particular tones that deflect the needle, and the large circle labeled CDI, course deviation indicator, in the case of a glide scope, for example, is the needle that -- is the meter that the pilots look at, the fly-up and fly-down indication.

So, the fly-up/fly-down needle is an indication of the difference in strength of those two tones, and the difference will be zero, and the needle will be centered when the two tones are equal, and as I mentioned earlier, we -- we go to great lengths to arrange the antenna system on the ground so that those signals are equal at the three-degree glide path.

Now the flag circuit, the other indication that the pilot sees, is driven by a signal which is the sum of the two circuits or the two signals. As long as the 90 and 150 signals are both present at sufficient strength, the flag will remain out of view.

So, the pilot looks at a different signal, which is the fly-up/fly-down, and at a sum signal, although he probably is not aware that it's a sum signal, that activates the flag.

MR. PHILLIPS: Now I -- the localizer works in the same manner as the glide scope, just turned off axis?

THE WITNESS: That's correct. On a different channel, we transmit the same two tones with an antenna system that assures that the tones are equal in signal strength on the runway extended center line, and that drives another needle which has fly-right and fly-left movement, and that needle stays centered again when the two tones are equal in strength, and a separate flag for the localizer is driven by the sum of those two circuits or two signals.

MR. PHILLIPS: So, then when a flight crew dials in a frequency for the instrument approach, they're actually tuning two frequencies?

THE WITNESS: That's correct. The -- the published frequency of the instrument landing system, for example, 110.3, is that of the localizer. The glide scope is paired in a pre-defined way so that the pilot need not also specify this second frequency, but two receivers are being set up on two different channels by that one action of setting 110.3.

MR. PHILLIPS: I see on the bottom of your chart, you have two -- two peaks there that say filter response versus frequency. Would you like to discuss that?

THE WITNESS: Well, yes. Because you asked earlier about what sort of signals could cause the flag in particular to move, we have to know a little bit about the filters that drive that flag circuit.

The bottom figure shows in a general sense how the output of the filters varies for a constant input signal of differing frequencies. To use my two notes on a piano analogy, if you were to play five or six notes on the piano centered around the 90 hertz frequency, only the one that corresponded to 90 would produce, say, a one-volt output of the filter, and as you played other notes at the same level of volume, because they're not at 90 hertz, not at the center of that frequency response for the filter, less and less of the equal -- equal amplitude input signal would be output.

So, as long as the ground station transmits only 90 and only 150 signals, these filters, the 90 and 150 filters that feed the fly-up and fly-down needle and the flag circuits, output equal amplitude signals when the airplane is on course and on path.

If the channel were empty, no ground station transmitting, no intended ground station, and some other signal, for example, a two-way radio with someone speaking on it, should somehow get through the frequency-determining circuits, then those portions of the signal that contain 90 and 150 tones, those portions of the voice, for example, or a music program would still get through those filters and could cause the -- the two needles, the sum and difference needles, to deflect in brief ways.

My voice, for example, contains 90 and 150 hertz components. Music contains frequencies in those ranges. So, depending on the shape of the filters response, which varies from receiver to receiver and from manufacturer to manufacturer, the flag and cross-blender circuits would see varying amounts of intermittent deflections, depending on the content of this spurious signal. As long as it contains 90 and 150 components or frequencies close to them, there's a potential that the needles will deflect.

MR. PHILLIPS: So, then would the -- using that discussion, would the most effective filter be one that had the steepest slope about 90 and 150 hertz points?

THE WITNESS: Yes. When -- when -- when you build the filter for any purpose, you want it to be as selective as possible or as reasonable. The two general curves that I've drawn there are somewhat typical. As -- as technology improves and costs of circuits get lower, it's more common to see narrower and narrower response curves. So that only frequencies very close to 90 and very close to 150 get through to the sum and difference indicators.

MR. PHILLIPS: Then would the effect of this be fewer erratic needle movements and flag movements?

THE WITNESS: That's -- that's correct. In the general sense, the -- the newer the receiver, the sharper the filters, the less often a pilot would see short duration flag pops and needle movements from an empty channel.

MR. PHILLIPS: Assuming we had an empty channel, if we had an intermittent flag, what would the needle be doing or what -- what would you expect it to be doing?

THE WITNESS: Well, for the flag to move, that means that the sum of the output of the two filters has to exceed some threshold that's been previously set.

The flag, of course, cannot tell whether the output from the 90 filter or the 150 filter or both are contributing to the signal that moves the flag. So, it's not possible to say in the general case whether the CDI will stay centered in the case of equal amounts of 90 and 150 or deflect up or down or right or left.

If the external undesired signal was composed of music, for example, the base notes in the music would vary. They wouldn't always be 90 or 150, and therefore if there were enough signal getting through the filters to move the flag, sometimes the needle would deflect up or right, sometimes it would deflect down or left. It's just very difficult to say.

But in the general case, it's random because voice and music and most signals that are transmitted by radio systems do not have 90 and 150 as an intended information source, and therefore those components that happen to be at 90 and 150 are time-variant.

CHAIRMAN FRANCIS: Could I interject a question here? If it's possible, could you characterize the relative sophistication or modern -- how modern the -- the receiver in KAL-801 was in terms of the narrowness of peaks?

THE WITNESS: Yes. I would -- I believe -- I would say that the KAL receiver was fairly typical for recent receivers. There are newer and sharper filtered receivers available, but it is -- the filter response characteristics of that receiver are pretty common. Quite a few other models from various manufacturers have similar characteristics.

The shape of those filters is defined by something called Q, a quality factor, and to get a high-quality factor in a very narrow filter shape takes some more components or some software in the general case. Most of the manufacturers use pretty similar techniques.

As the receiver model generations change over time, the filters typically get narrower, just because it's convenient and cost-effective to make them so, but there are many receivers in service, like the KAL receivers.

MR. PHILLIPS: Okay. One step back here in your description of the deflection without an intended signal, would we need a fairly constant tone then, either a 90 or a 150 hertz range, to cause a steady needle deflection in the absence of a normal glide scope.

THE WITNESS: Yes. Whatever type of signal gets through those filters, it would have to have -- the amount that got through the 90 filter and the amount that got through the 150 filter would have to be fairly constant, so that the difference between the two is constant, and the needle would deflect to a consistent value.

MR. PHILLIPS: In looking at your example of filter response versus frequency on the bottom of the chart, it would appear that approximately halfway in between the 90 and 150 hertz frequencies, at about 120 hertz, the filters would be the least selective, is that true?

THE WITNESS: Yes, that's correct. Where those two responses cross, which can be 120 or 122, it varies a little with the model number, but it's approximately 120, a single tone of that fixed value would get through the filters equally well and would result in, if it were strong enough, a centered needle.

MR. PHILLIPS: Okay. That leads us to a discussion regarding some post-accident testing conducted by Korean Air Lines.

Have you been briefed, and are you aware of those tests and results?

THE WITNESS: Yes, I have.

MR. PHILLIPS: Okay. Would you like to summarize those or would you like me to?

THE WITNESS: I'll take a crack at it.

MR. PHILLIPS: Okay.

THE WITNESS: The Korean Air Lines test basically said what -- what type of signal could cause the flag to disappear from view and cause the CDI to remain basically centered, and -- and since all of us in the business are aware of these filter shapes, as you pointed out, if you had a signal on channel that had in this case 120 hertz modulation, a single tone, it wasn't an ILS signal but it was some other signal, and if that tone were strong enough, you notice that the response of the filters at 120 is rather low, but if the strength of the 120 signal were strong enough, the music were strong enough, the voice were strong enough, for example, then the signal that gets through both filters and is summed in the flag circuit might be sufficient to cause the flag to move.

So, they bench tested such a scenario, a signal generator with modulation of a 120 hertz, quite strong, roughly twice as strong as the typical glide scope 90 and 150 tones, and -- and found that on a variety of receivers, they were able to cause the flag to disappear from view.

Because the filters have a roughly equal response at 120, when the flag disappeared from view, the -- the cross pointer fly-up/fly-down indication was roughly centered, and it would vary from receiver to receiver because the filters are not identical at 120 in every case, but over a wide range of manufacturing choices, most of the receivers have an equal response at approximately 120.

So, -- so, they found out of six different models of receivers from several different manufacturers, four of them, those with the broader filter characteristics, would allow the flag to disappear from view, and two of them with narrower filters left the flag in view.

CHAIRMAN FRANCIS: Any indication of how long that might be -- disappear from view than the -- than the less-precise ones?

THE WITNESS: Well, of course, their tests were static with a continuous signal from a test generator, just to show that the receivers would indeed respond if such a channel -- such a signal were on channel. So, these were -- so far, I've described just bench tests.

CHAIRMAN FRANCIS: I assume we're getting to that.

MR. PHILLIPS: Yeah. Do these results surprise you in any way? Are they what you would expect?

THE WITNESS: They're what I would expect, given the nature of receiver design.

MR. PHILLIPS: Okay. Based on -- on these tests and -- and what you've seen and the testimony this week or what you've heard, do you believe that the warning flags are adequate to protect from interference or -- or spurious movement?

THE WITNESS: Well, no. This -- this type of circuit is intended to warn of failures in the ground ILS station or -- and in the receiver and -- and does not address other types of signals which may have 90 and 150 components.

Obviously any type of signal that's on channel, instead of intended ILS station, if it has the right characteristics in the audio, music and voice and so on, this type of flag circuit, which is used extensively, cannot discern the difference between the intended ILS signal and an extraneous one that has the right characteristics that last long enough.

MR. PHILLIPS: Along those lines, at an instrument landing system location, how do we design or how does the FAA protect the local environment so that those tones and frequencies are predominant?

THE WITNESS: Well, the Federal Communications Commission, which, of course, manages the spectrum in the U.S., has granted to the FAA the management of those bands of spectrum that -- on which the ILS operates.

So, in the general case, of course, we assign instrument landing systems so that any two which are on the same channel are sufficiently far apart that a single aircraft cannot receive two of them at one time.

As far as out-of-band signals go, such as paging transmitters and all sorts of personal communications devices, any time someone is going to construct a station within about four miles of an airport, we have a requirement that they notify us and obtain approval for installation of those stations.

In my region, for example, we see about 30 of these applications a week, and each one is examined for its signal strength, its frequency, its potential to affect radar systems, microwave systems, instrument landing systems, and so on.

So, in that sense, we have a regulatory control over how close and what nature of transmitters are installed close to an airport. So, as long as all of these emitters operate in the way they are intended, the -- the frequency band can be kept clear of non-ILS signals.

MR. PHILLIPS: You noted that in the way they were intended. Does that imply that there's a possibility that an unintended operation could have an effect?

THE WITNESS: Well, surely. Just like any -- anything that we own, like a car or a microwave oven, after some time, transmitters may degrade or fail in ways that cause them to transmit on incorrect frequencies or have incorrect characteristics, and when that occurs, there is a potential in -- in any radio-type system for other systems to be affected.

So, the protection of the navigation frequencies for this condition is basically a reactive one. There's no way to predict when to continue picking on the paging folks, for example. There's no way to predict when a given transmitter is going to fail in such a way that it may transmit incorrectly on frequencies other than is intended, and when we get reports from pilots or from our flight test folks of such occurrences, then we send out folks specially equipped to locate those ground stations and get them corrected.

MR. PHILLIPS: So, you're very dependent on the way the system is structured today to find the faults with the system?

THE WITNESS: That's correct. Changes in the electromagnetic environment, changes in the spectrum, changes in non-navigation systems on or near an airport are detected in general by the users. There's no present way to monitor throughout an approach, for example, the -- the cleanliness of the ILS spectrum.

MR. PHILLIPS: Does the Guam Airport area present any unique characteristics as far as ILS system approaches go?

THE WITNESS: Well, I think not. It's certainly got a lot of terrain, but we have many airports with terrain. We have -- when you have high terrain, you have hilltops and mountains which are very advantageous for other transmitting systems. People like to get their transmitters up at a high location. So, it's fairly common that we will have AM and FM broadcast stations and various personal radio systems in and around airports and on high locations.

MR. PHILLIPS: There's a military base on the other end of the island at Guam, which operates an ILS system that's approximately aligned with the Runway 6 Left system at Agana.

Would you expect that to have any effect on the Agana, Guam, approach?

THE WITNESS: No. The -- the two ILSs that you speak of, the one at International and the one at the Air Force base, are, of course, on different channels because of the spectrum management activity that I spoke of earlier.

One of the components of assigning frequencies for ILSs is to assure that nearby ILSs are sufficiently apart on the radio dials, sufficiently apart in frequency, that common receivers can easily separate the two.

MR. PHILLIPS: Does the FAA maintain any kind of a database relative to interference or spurious signal cause and effect?

THE WITNESS: Yes. I'm a little hesitant about database. We have a logging system and a reporting system for interference cases, which may appear in some cases to look like a database, yes.

MR. PHILLIPS: Okay. Just a few closing comments here. I would be interested in your comments about future avionic systems designs relative to ILS systems, and in particular, the proliferation of electronic cockpit displays and the potential effects on the ILS systems navigation units.

Do you see a trend toward improving the margin of safety with the newer avionics versus the older designs?

THE WITNESS: Well, yes. As I mentioned earlier, it is increasingly easier and less expensive to produce better and better receivers. We've all seen how electronic systems continue to get cheaper in cost and generally have better and better performance.

So, receivers in general aboard aircraft are increasingly capable, and -- and now we are seeing a single box that has microwave landing system, instrument landing system, and global positioning system receivers all in the same space that a single receiver used to occupy.

Increasingly, with more and more software-based systems, the amount of hardware required is less. This means that the receiver itself has less complexity, less potential for failure and so on.

On the other hand, the software has the potential for failure, and, so, software quality assurance is becoming a very large component of receiver design.

The displays in aircraft are becoming more and more cathode ray tube and flat panel-based. These displays have a lot of electronics to drive them, and any electronics has a potential for generating signals. So, there's a corresponding increase in the amount of testing to ensure that on-board systems don't affect on-board receivers.

So, the standards bodies have been adding more and more tests for -- to ensure compliance that the signals emitted by circuits aboard the aircraft are not affecting aircraft receivers.

MR. PHILLIPS: And as a final question, are there active working groups in the aviation community looking at the issues of interference, spurious signals, and ILS system improvements?

THE WITNESS: Yes. Most aviation authorities have their own. For example, FAA has several, and I serve on a couple international committees which are editing and improving, updating ICAO and X-10, the document used worldwide for ground and airborne testing of nav aids and so on.

In general, to keep up with the changing environment that receivers operate in, higher and higher power broadcast stations and so on have resulted in a requirement, for example, starting very soon, that aircraft operating in international environments have to have a new receiver that's more immune to these off-channel signals.

MR. PHILLIPS: Do you expect in the future to see ILS systems replaced with another precision landing system?

THE WITNESS: Great question.

MR. PHILLIPS: My last one.

THE WITNESS: Certainly that is the general goal of most aviation authorities, is to migrate to satellite-based systems. However, there's a large portion of the avionics community that feels that at least as a back-up system, some small portion of the existing instrument landing system installation should be kept. So, I believe the technology will support moving to satellite systems.

MR. PHILLIPS: Thank you. That's all I have.

THE WITNESS: You're welcome.

CHAIRMAN FRANCIS: That's interesting. It's possible we'll get through the whole morning without talking about MLS.

I'd like to just make a comment and an observation here for those in the audience, and that is both at the NTSB and the FAA, we have what are called national resource specialists, and -- and these are people who, because of exceptional qualifications and international reputations, are designated to operate in certain areas.

It turns out that both Mr. Spohnheimer and Mr. Phillips are national resource specialists, and I think that the exchange that we've just witnessed is evidence of why they are. That really was extraordinarily interesting and informative.

Thanks to both of you.

I would now say to all of us here concerned that we would -- we would like to keep things moving along. So, let us all of us keep in mind that which has been said and try to avoid redundancy in our questions or going on longer than is necessary.

KCAB?

MR. LEE: Thank you, Chairman.

Mr. Phillips put special technical questions, and Mr. Spohnheimer gave us excellent answers, and I'd like to take this opportunity to appreciate both of you gentlemen.

Just one thing. Let me just double check. The KAL accident, the location was, as you know, --

CHAIRMAN FRANCIS: I thought he was so good that he'd be able to operate without one. Go ahead.

MR. LEE: The location of the KAL accident is Nimitt Hill, as you know. There are antennas and many other radio facilities located also in that area.

Given that, do you think in your personal view from the vantage point of a specialist, do you think all those radio facilities had any effect on the accident?

THE WITNESS: Statistically, I think it is unlikely, but it is very difficult to say with any certainty without some testing, and -- and even so, the nature of spurious signals and the failure modes that produce them means that as antenna systems change and deteriorate, the conditions change.

Certainly we have -- most airports are challenged with the same sorts of problems. I would offer in general that -- that I probably am aware of five or 10 cases in a given year of interference to an instrument landing system in the case of several hundred ILSs.

So, the occurrence is not rare, but it's perhaps in the one to five percent range.

MR. LEE: Thank you very much. That's all.

CHAIRMAN FRANCIS: Boeing Company?

MR. DARCEY: We have no questions, Mr. Chairman.

CHAIRMAN FRANCIS: Barton?

MR. EDWARD MONTGOMERY: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: Korean Air?

CAPTAIN KIM: Yes, sir. We do have a question.

Not to delay the process, but would you please tell us if FAA ran any kind of testing on the localizer signal, interruptions or deviations, as well as the Korean Air-run glide scope testing, bench testing of similar nature to the localizers?

THE WITNESS: I'm not aware of any bench testing on localizer receivers associated with this accident. As I did mention, we -- we flight tested the localizer in the day or two following the accident.

CAPTAIN KIM: Right. The question is referring not to flight testing but bench testing with similar set-up to verify the results as Korean Air did.

THE WITNESS: No, I'm not aware of any testing. I would expect the results to be similar, however, that -- that one could inject signals that would cause the flag to move.

CAPTAIN KIM: Okay. Thank you very much.

May I ask you one more question? So, are there any plans underway to continue testing at Guam, in specific to find out if there are any more things to be discovered regarding this accident?

THE WITNESS: I'm not aware of explicit plans, but there has -- I have been a participant in some discussions about the nature of ways we might test the Guam environment more fully.

I did request an extra airborne test just recently to make some recordings of the ILS with the glide scope off the air. That was done within the past week. It took perhaps 45 minutes. So, it is only a very short look at the nature of the spectrum at Guam with the glide scope off the air. Nothing was found on that particular check, although it was a very short one.

CHAIRMAN FRANCIS: I think Mr. Phillips might supplement that answer.

MR. PHILLIPS: Yes. I'd like to comment on that. The systems group has had discussions concerning plans, potential plans for additional site testing at Guam in an attempt to identify potential signal sources.

One of the issues you may be aware of is that after the accident, there was a typhoon passed through the island that did considerable damage to the antennas and transmitting system there.

So, we believe that the environment at Guam today is different than at the time of the accident, but nevertheless we intend to -- to set up a plan to go take a look for -- for potential spurious signals. So, that's an activity that we'll be discussing in the systems group over the next couple of months.

CAPTAIN KIM: I'm sorry to delay, but we have one more question, and we have about 30 seconds before we ask this question, Mr. Chairman.

CHAIRMAN FRANCIS: Why don't we go to the other parties, and then we'll come back to you.

CAPTAIN KIM: I apologize. Thank you.

CHAIRMAN FRANCIS: NATCA?

MR. MOTE: Thank you, Mr. Chairman. Just a very brief question.

Sir, do you haveany opinion as to the -- any particular technical difficulties, and just in very general terms, the cost of co-locating DME facilities with the ILS transmitters?

THE WITNESS: Yes. The cost of installation is quite minor, perhaps $10,000, if there's an existing building with enough room. The equipment, DME equipment, would be perhaps $100,000.

MR. MOTE: And are there any particular technical considerations regarding such an installation?

THE WITNESS: Well, there are many, but none particularly challenging. We have many installations with localizer and DME co-located.

MR. MOTE: Thank you very much, sir. No further questions.

CHAIRMAN FRANCIS: Steve, you ready?

CAPTAIN KIM: Yes, sir. We're prepared at this time. I understand there's not conclusive evidence to continue further testing of the equipment.

In particular to the Model 51RV-5B, are there any plans underway to improve the safety performance of this equipment in particular?

THE WITNESS: I'm not aware of any, but I haven't spoken to the manufacturer recently either.

CAPTAIN KIM: But nothing will be initiated from the FAA's part to mandate any kind of further improvements on that model?

THE WITNESS: I don't know how to answer that. I -- the avionics group, which happens to be located in Seattle but a different part of the agency than myself, would -- would have to initiate some dialogue to -- to promote such a change.

I take it you mean about the flag circuits?

CAPTAIN KIM: Yes, sir. You just described the process you would -- that's how you would go about it, but are there -- do you have specific plans at this point to initiate or mandate specific improvements to that model by the FAA?

THE WITNESS: I know of none.

CAPTAIN KIM: Thank you very much.

CHAIRMAN FRANCIS: Government of Guam?

MR. DERVISH: Thank you, Mr. Chairman. No questions.

CHAIRMAN FRANCIS: Mr. Donner?

MR. DONNER: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: Mr. Feith?

MR. FEITH: No questions, sir.

CHAIRMAN FRANCIS: Mr. Montgomery?

MR. MONTY MONTGOMERY: Thank you, Mr. Chairman. I have just a couple short ones.

Mr. Spohnheimer, for the benefit of those of us who are not as technical as our national resource specialists, when we talk about injecting signals into the -- the device to see its response to a 120 hertz, I -- I -- I hear you say things like you just somehow squirt base band information in the system, and it responds in a way that's -- that's unsatisfactory.

However, in reading the report here, I find that they actually put this on top of an 88. -- 83.75 megahertz carrier in one instance and a 355 megahertz carrier in another instance. In other words, it takes a special way of doing this in order to get those base band frequencies in there, is that correct?

THE WITNESS: That's correct. The base band frequencies, the tones that we've been speaking about, are -- are called the modulation, and the carrier is the VHF or UHF signal that a pilot would tune a control head to.

So, in all cases, when I spoke of a signal generator, that was referring to a piece of laboratory equipment that could both generate the very high frequency signal, the numbers you're referring to, and add the tones to that signal.

MR. MONTY MONTGOMERY: So, if I walked up to this piece of equipment and played my radio real loud at a 120 hertz, it's not going to have any effect?

THE WITNESS: That's correct. I'm sorry if I left you that impression. The circuits that are sensitive to audio tones, of course, there's no microphone connected. They listen to those frequency-determining circuits that I had in the block diagram, and those circuits are the ones that limit the incoming signal to radio signals in the desired band.

MR. MONTY MONTGOMERY: And the modulation type, is it FM or AM?

THE WITNESS: This is amplitude modulation.

MR. MONTY MONTGOMERY: AM. So, if I flew over an FM station playing at 10 kazillion megawatts, what effect might that have?

THE WITNESS: Well, unfortunately, it probably would, even though the receiver is intended to respond only to amplitude modulation.

When -- when an FM signal is strong enough, it can actually affect the operation of the circuits and add amplitude modulation to the signal. So, a somewhat common occurrence among the interference cases is an aircraft operating close to a mountaintop-located FM transmitter.

So, the AM receiver is not immune to FM and vice versa.

MR. MONTY MONTGOMERY: Okay. Thank you very much. Thank you, Mr. Chairman.

MR. SCHLEEDE: Yes, Mr. Spohnheimer, I just wanted to follow up on one area you mentioned about the possibility of doing some testing at Guam to look for some problems.

Do you have any recommendations for us regarding our investigation whether we should be doing additional testing or the FAA should be doing additional testing at Guam?

THE WITNESS: Well, my view is that the FAA should be involved and perhaps has an incumbent responsibility to do something out of the ordinary to assure that there are no -- no extraneous signals affecting ILS.

The difficulty with all of this testing is that if -- if an extraneous signal is due to another user or to a degraded transmitter of some sort, they're seldom continuous. They're usually intermittent, and sometimes it takes a very long time to locate something that's clearly been reported.

It's like proving a negative. You can -- you can flight test it for a week or two weeks, and if you haven't found anything, you can't say that it didn't exist. Obviously if you find something right away, then you're done, and you can go fix it.

So, I think it would be reasonable to -- to define a -- a short test program that had a definite end to it that made a diligent effort to confirm that the spectrum is clear in the area of the approach.

MR. SCHLEEDE: And would the -- would the pilots that fly in there certainly play a factor in reporting outages or -- I'm sorry, not outages, spurious signals?

THE WITNESS: Yes, they would. The sort of thing that an engineer would probably do is -- is haul some test equipment out to the area and set it up with a computer so that it logs the conditions automatically every so many minutes for -- for some hours or days, so that we have actual measurements using lab-type equipment as opposed to user complaints.

But if there were approaches being flown at the time, it would be easy to add that sort of information certainly.

MR. SCHLEEDE: Thank you very much.

CHAIRMAN FRANCIS: Mr. Berman?

MR. BERMAN: No questions.

CHAIRMAN FRANCIS: Mr. Cariseo?

MR. CARISEO: No questions.

CHAIRMAN FRANCIS: Thank you very much, sir.

THE WITNESS: You're welcome.

CHAIRMAN FRANCIS: That was a very helpful and impressive performance, and those of us that travel a bit have -- are particularly impressed by anyone who travels 40 weeks of the year, and I won't ask you about your family status.

THE WITNESS: Thank you.

(Whereupon, the witness was excused.)

CHAIRMAN FRANCIS: We have five witnesses left. Three of the five, including Captain Woodburn, who is the next witness, are, I think, a little unusual for an NTSB hearing, but I thought that it was interesting to -- to perhaps have a little wider perspective on some of the issues that we consider important here.

So, Captain Woodburn is a captain with British Airways. He and I worked together on a number of committees, many of which are -- are involved with the CFIT issue, and I think that he can give us a contribution in terms of the overall worldwide implications of this kind of accident, and the same will apply to Don Bateman and to Jim Terpstra.

Mr. Schleede?

MR. SCHLEEDE: Thank you, sir.

Whereupon,

CAPTAIN PAUL WOODBURN

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

TESTIMONY OF

CAPTAIN PAUL WOODBURN

BRITISH AIRWAYS

CHAIRMAN, ICAO, CFIT STEERING COMMITTEE

LONDON, ENGLAND

MR. SCHLEEDE: Captain Woodburn, please give us your full name and business address for our record?

THE WITNESS: It's Captain Paul Woodburn of British Airways PLC, The Compass Center, Heathrow Airport, London, England.

MR. SCHLEEDE: And would you please, because you're called here as an expert in this field, give us a summary of your experience and training and education that qualifies you for your current position and status?

THE WITNESS: Yes, sir, I will. I've been 34 years of flying with British Airways, 25 years as a captain and currently a captain on the Boeing 777.

I also have 23 years of flight management experience, the past 12 in senior management positions.

I also have 20 years of other industry experience having served on a number of industry committees and various projects. One in particular concerns this inquiry, and that is the Flight Safety Foundation initiative commenced in 1992 into Controlled Flight Into Terrain, CFIT.

I was a founding member of the original steering team. I have served as a member of the CFIT equipment team, and I'm now currently the chairman of the steering team for the past 18 months and a member of the implementation team for both CFIT and approach and landing accident reduction.

I'm also a Fellow of the Royal Aeronautical Society and a liveryman of the Guild of Air Pilots and Air Navigators.

MR. SCHLEEDE: Thank you very much.

Dr. Brenner and Captain Misencik will question.

DR. BRENNER: Mr. Chairman, we've asked Captain Woodburn to prepare a presentation about the industry efforts. With your permission, we'd like to have him present that.

CHAIRMAN FRANCIS: Go ahead.

THE WITNESS: Mr. Chairman, ladies and gentlemen, as you are expecting, I have a short presentation here to explain, I think, the problem of CFIT so that we can all understand it and, of course, to explain the Flight Safety Foundation initiative and to discuss some of the recommendations.

CHAIRMAN FRANCIS: Paul, could I just sort of reiterate the reminder that the interpreters are trying to follow you. So, I suspect that you're going to be more easily understood by them seeing as you're speaking real English, but -- but if you could sort of modulate your speed, I think they'd appreciate it.

THE WITNESS: Okay, Mr. Chairman.

I start with a definition of CFIT. There is no internationally-agreed definition, and the one on the screen in front of you reflects the one we chose for our work in the Flight Safety Foundation.

CFIT is when a perfectly-serviceable airplane is inadvertently flown into the terrain or water.

Can I have the next slide, please? Here you can see some statistics on controlled flight into terrain, and this reflects worldwide experience. On the bottom axis are years from 1968 through to 1997, and the vertical axis are the number of accidents predominantly to jet aircraft.

Over on the left-hand side, you can see where GPWS was introduced alongside the highest peak.

CHAIRMAN FRANCIS: Could we turn the lights down a little in here so we can perhaps get a little more better look at this presentation?

THE WITNESS: And you'll see the relatively dramatic reduction thereafter.

Over on the right half of this particular visual, you can see highlighted blocks, and I would draw your attention to the two peaks that stand up there, and they reflect the years of 1988 through to 1991, and then, of course, in 1992, there is a second peak, and this appears to be a regular characteristic of CFIT data.

There is a cyclical action here. Over three to four years, there is a rise to a peak, and then it diminishes. We don't necessarily know the answer for it, but we believe it's related to industry awareness.

When it reaches a peak, there is so much media attention and awareness that there is a natural, I think, reaction to it and therefore could explain the reduction.

It was that peak in 1992, the second of those two peaks, which led to the Flight Safety Foundation starting its initiative into CFIT and approach and landing accidents.

Next slide, please. Here you can see which sort of airplanes CFIT is attached, and you can see over on the bottom left side there, there are approximately five large commercial jet accidents on average per year worldwide, and this was the data that we had in 1992.

Interestingly, you can see the impact on large turbo-prop, regional commuter turbo-prop, business jet, and business turbo-prop aircraft, and over on the right-hand side there, the business turbo-prop have an average of 23 losses per year.

Next slide, please. This particular slide just shows from 1992 in top left there the initiation of the Flight Safety Foundation initiative. That led to a commitment and then formation of teams. I was involved from that very early stage, and then, of course, the teams worked for several years, and the final working group reports were delivered towards the end of 1995.

A further year was taken refining what we now know as the CFIT Education and Training Aid, and that became available towards the end of 1996, being distributed to industry in early 1997.

So, the bottom two lines there are concerned with Flight Safety Foundation implementation team activity which continues and the application of the associated products.

Next slide, please. Why did we concentrate our attention on CFIT particularly? This is worldwide and U.S. airline fatalities classified by type of accident over a 10-year period. The highest peak on the left-hand side there are the fatalities due to CFIT.

The next highest peak is the loss of control in flight, and that's another story, and it's because this particular peak of CFIT there that there has been so much industry activity.

Next slide. Where does CFIT occur? The simple answer is worldwide. This particular slide shows western-built commercial jet transports again up through to 1997. This is just a five-year period, and this is the latest data and not the data that we saw when we started our work. But let me talk you through this.

First and foremost, in the middle, in Eastern Europe and the Middle East, the figures of zero are not really zero. They are areas where we have insufficient data.

If I can turn now to North America, and you will see an accident rate there of .03. That has been pretty stable over a long period of time at that value. But over there adjacent to it, you can see Europe at .10. In other words, three times worse than North America.

Coming down to Latin America, you can see the figure there at 1.12, and that is a figure of 37 times worse than North America. These are CFIT accident rates.

Moving across to Africa alongside, that figure there is 18 times worse, and then moving across to Asia Pacific, these figures are 23 times worse or down in Oceana, 11 times worse than North America.

They sound terrible figures, but I have to say that since we started this initiative, the worst figures that we saw before were in Africa, which were 70 times worse. So, there has been a significant improvement from 70 times to 18 times, whereas in Latin America, there has been no improvement whatsoever. That figure is still 30 times -- 37 times as bad as North America. So, this gives you a measure of the size of the worldwide problem.

Next slide, please. If we can concentrate over on that right-hand bottom corner, where it gets into 1997, if we can just move it slightly, you'll see here the same block diagram that we looked before, but what I'd like to concentrate on is that for 1996 and '97, those black boxes, they are three CFIT accidents per year for '96 and '97. All of those black boxes were non-precision approaches. In other words, five out of six accidents in those two years were on non-precision approaches.

Indeed, the accident data shows that the risk on non-precision approaches is five times greater than for conducting precision approaches.

Next slide, please. Here, we're looking at commercial jet aircraft, again a 10-year period, from '88 to '97, and this is where these accidents occur on what type of approach, and there's 38 accidents here worldwide. The very large blue block there, which is roughly half of the cheese, half of the number, were on step-down approaches.

The interesting thing is most of those had DME available. There are only three accidents there which are over at the 8:00 to 9:00 position on precision approaches, and they relate to probable glide scope receiver failure, probable failure of a flight director to capture, and also a possible autopilot not being coupled. But they're a relatively small proportion of the whole, and the interesting thing is that 70 percent of CFIT accidents occur on final approach.

Non-precision approaches generally are much more complex than precision approaches. For many pilots, they are less familiar. They are more error-prone. They require more comprehensive briefing. They need particularly careful and accurate monitoring, and it is possible for complex step-down procedures for steps to be missed or to be taken out of step. In other words, to get one step ahead of the airplane could be fatal.

Such approaches also need much more carefully-managed airplane crew and checklist management, and it is a characteristic of many CFIT accidents that they occur when the crew is pre-occupied or distracted by other tasks.

Next slide, please. Where do they occur? As I mentioned, 70 percent on final approach, and that solid red line in the middle is where most of these accidents impact the ground. They're all in line with the runway, and, fortunately, as we shall see for the next slide, you can see here an idealized three-degree glide scope in orange, red, and then these are the flight paths of many accident aircraft underneath the three-degree glide scope. In other words, following paralleling a three-degree glide scope but impacting the ground on extended center line but short of the runway.

The parallel to Agana, Guam, is obvious.

Next slide, please. The Flight Safety Foundation overall goals were to reduce the CFIT accident rate by 50 percent in five years and that's this year.

The latest data that we have available shows that this goal has actually been achieved, albeit the data is still being assembled, and I have not got it to show you today.

The second goal here was much more challenging, and if you remember those worldwide accident rates I showed you, the worst in 1992 being 70 times worse than North America, under this basis, we would be looking for a rate no worse than twice North America.

So, we've made some improvement but certainly not to the extent of this particular goal that we set ourselves.

Next paragraph. So, who was involved on this industry participation? With the Flight Safety Foundation, we brought operators, manufacturers, to some extent regulatory authorities, although I have to say that the degree of participation by regulatory authorities has been disappointing. There was very little direct involvement in any of the working groups by any of the regulatory authorities worldwide.

However, they were kept informed of what we were doing either through the Flight Safety Foundation or by direct contact. Flight Safety Foundation also represents training organizations, and we had good participation there.

Wherever the Flight Safety Foundation found another initiative already going, we combined resources, and then everything was put under the Flight Safety Foundation banner, and that brought in ICAO, IATA, IFALPA, ALPA, the ATA, and again the ATC authorities.

Like the regulatory authorities, the ATC authorities were reluctant participants, too. The interesting thing for all of this industry activity, it's not just organizations but represents hundreds of individuals who have worked with us, some of whom still work with us on this particular initiative.

ICAO is normally recognizedsaa body that takes five to seven years to do anything, yet it has been remarkably supportive and productive to this process. Since 1994, there's a lot that they've done as we shall see.

Next slide. So, let me just recap on CFIT. It is this inadvertent flight into terrain or water. It does cause the greatest number of fatalities. The risks on non-precision approaches are greater, and they almost always involve the breakdown of crew coordination and monitoring.

Another factor which became very strgoly evident in the analysis of all of this work was that there is no single measure that we can take to prevent CFIT. It needs a range of measures suited to a particular operator and the operating environment.

There is no new single piece of equipment that can be fitted to aircraft that will make CFIT go away. Yes, it may help, but in isolation, it is not the sole cure.

Remember also that any new equipment requirement takes many years to implement across the entire industry, and in many ways, it's the areas of the world that have the least problem that will fit the equipment first, and it's those other areas of the world where the greatest problem exists that will fit it last.

Industry must therefore take action now because we can't afford to let this risk go on unaddressed.

Next slide. This ICAO requirement becomes effective on January 1st, 1999, and if you remember the earlier slide in terms of small aircraft CFIT exposure, this was aimed at applying GPWS-fitted to the smaller airplanes.

You still have to remember that there are up to 200 heavy jet aircraft flying in the world today that have no GWPS-fitted at all, even after 20+ years of requirement.

Next slide. The GPWS warning functions described here are in effect the characteristics of a Mark-2 or subsequent model of GPWS, and the effect of this rather more stringent set of requirements for ICAO is that the early Mark-1 GPWS installations will need to be replaced by Mark-2 or better.

Next slide. There are a number of other changes that are being pursued in terms of instructions and training requirement for the avoidance of CFIT. There is also the requirement being framed for a company policy on the use of GPWS. Proposals in this direction being very detailed, which is why I'm not going through them here today, were being presented to the ICAO Council only last week. We await progress reports.

Next slide. This is a whole series of future ICAO actions, and I will only mention briefly some of the things associated with these headings.

Under the licensing and training, Annex 1, the proposed changes there are mainly to do with air traffic control language, skills and proficiency with requirements for improvement by 2001.

The next one down, charting, is concerned mainly with the adoption of colored terrain all minimum safe altitude contour presentation on charts to improve their readability and understanding by flight crew, particularly in the cockpit environment at night.

Operation of aircraft, the third bullet down there, there are a whole range of things, whether they be equipment and procedures, but typical things being discussed there are prohibition of the old altimeters, things like three-pointer designs or fixed drum-pointer design of altimeters which can easily be misread. There are still many in the industry in use today.

Under equipment, there is a requirement, an extension of requirement for ACAS, pressure altitude encoding transponders, forward-looking wind shear warning systems, and others.

Under procedures, there are new requirements and new emphasis on standard operating procedures, altitude awareness procedures, including the use of standard or automated call-outs, guidance on the use of autopilot, the incorporation of stabilized approach procedures concepts, etc.

The next one down, instrument approach procedure design, under PANS-OPS, there are particular changes there applicable to non-precision approaches concerning the optimum angle, and, of course, growing interest in the application of vertical navigation, VNAV, or FMC approaches.

Under air traffic services, there are new requirements regarding radar vectoring to avoid GPWS alerts as well as emphasizing and encouraging the implementation of MSAW of which we've heard a lot on this inquiry.

The last bullet there in terms of publishing a manual on CFIT avoidance is still under consideration. Further activity with ICAO concerns the translation of the Flight Safety Foundation education and training aid into ICAO languages, the other five beyond English. We're still awaiting a time scale for that availability.

Next slide, please. So, in summary, these are the ICAO sorts of changes. There is a need to train to ensure pilot response to CFIT ground proximity warning systems and so on.

Now there are two different ways of doing this. Many operators use a technique of during normal proficiency checks, inserting what some call an imaginary or glass mountain which generates a GPWS pull-up alert unexpectedly.

The problem with that is that the pilots may have been operating perfectly normally, safely, under their proficiency check, and they then have what is a rogue warning that seems to come at them with surprise. That can be considered negative training because it causes them to mistrust their basic normal procedures.

Another way of doing it is to still show how ground proximity warning systems work but in a more creative way. I'll describe a way that I know well particularly, and I know a number of other operators use it.

Modern simulator systems have good visual displays. When operating to an airport in the simulator database, under VFR good visual conditions, in mountainous terrain, it is very easy to take a vector that puts the airplane flying towards a potential conflict with the terrain. The briefing to the crew is let it happen, see what it looks like, and don't do anything until the ground proximity warning pull-up occurs.

The pilots are then left with this situation of watching the ground approaching, eventually filling the windshield in the visual display, and still the pull-up does not occur, remembering that 15 seconds or so to impact is typical of the characteristics of such systems. It could be less or marginally more.

So, when they get to the pull-up point, they're on the edge of their seats, can't stand the sight of it, and then, of course, pull up, they do the pull-up maneuver, and hopefully, if they've done the right technique, having watched the ground approaching, they will follow the required escape maneuver. They then have this visual image of what it looks like to be that close to terrain.

The next part of the exercise is to repeat it all in a different area, different bit of terrain, but they're now IMC. They don't see the terrain at all. For you pilots out there, I can guarantee you've got that visual image with you for several years after the event of having done that exercise, and when you fly in IMC to the pull-up point, you remember what it looked like visually. You don't waste any time. You get out there very quickly indeed, and it is an aggressive maneuver needed. Gentle ones or time taken to say is this real or false is not a luxury that we can afford. Now that type of pilot teaching, I think, is very powerful and much more meaningful to them.

So, moving on to the second bullet there in terms of updating early ground proximity warning system installations, I've covered that in terms of Mark-1s being replaced by Mark-2 or better.

The third bullet is in terms of encouraging development and application of enhanced GPWS. We also need to provide precision approach glide scope guidance whether that comes from GPS, GNSS, RNAV, and so on.

I think we all recognize the need to eliminate the step-down non-precision approaches because the accident data says we should. We also need to encourage the expansion of approach radar coverage with MSAW on a worldwide basis, not just in the few countries that presently use it, and, of course, as we saw earlier, we're fostering the equipment of smaller transports with GPWS.

Now set against that, what actions have the regulatory authorities taken? Relatively little.

Now let's turn to the next slide, and here what I've tried to do, rather than go through a detailed presentation of all of the recommendations which would be beyond, I think, the scope of this inquiry, what I've tried to do is to show some of the applicable recommendations, and then I'll talk a little bit about them.

Chart supply and presentation. One of the recommendations was that looking at the worldwide data, a factor in some of the accidents was that not all crew members have charts. If they don't have charts, how can they effectively monitor what's going on?

So, there is a requirement that all crew members should have appropriate charts, and then, of course, the charts themselves in terms of presentation should have clear depiction of terrain and be easy to read in the cockpit environment. Hence the recommendation of colored contours.

The second bullet down in terms of approach and departure briefings, again the accident record shows that many of them have a failure to conduct adequate either departure or approach briefings. The more complex the approach, the more briefing and careful rehearsal of what is needed on that approach becomes necessary.

The third bullet down, allocation of flight crew duties and the use of the monitored or, as some call it, the shared approach procedure. An analysis of the accident data shows quite conclusively over hundreds of whole losses that they occur mainly in terms of IMC or at night, and on four out of five occasions, they occur when the handling pilot is the captain.

Another piece of data is that where crew coordination and monitoring is shown to be a causal factor for the accident, then it is four or five to one more likely to occur when it's the co-pilot monitoring the captain rather than the captain monitoring the co-pilot flying the approach.

That accident data therefore led to a recommendation that suggested that for IMC and night approaches, then the co-pilot should be flying the approach and the captain should be monitoring, and the captain takes over when visual reference has been achieved for the landing.

Now we all accept this question of the monitoring of the captain by co-pilots and so on is, I think, a worldwide cultural issue. The human factors experts have coined the phrase "the authority gradient". It applies to all nationalities, not just one particular nationality. All of us, I think, have a respect for rank, authority, experience, but in addition to that, there are some cultural issues, too.

It is more difficult for some cultures to be critical of the man in charge, the captain, or woman in charge than for some other cultures, and it doesn't matter how much training or whatever the company policies and procedures are, that has to be worked out continuously to achieve the correct, I think, crew integration and team effort. But all of that is part of this allocation of flight crew duties.

One other factor, a related recommendation, but I've not done it separately, is the use of the autopilot. Even for non-precision approaches, and probably particularly there, we've already discussed that it's a more difficult sort of approach. Why not use the autopilot? Because it reduces the workload. The handling pilot even operating the autopilot has more capacity to monitor what's going on and, I believe, will lead to a safer conclusion of that approach.

It does keep the workload well down, and I think improves this crew integration and monitoring enormously.

The last bullet is the non-precision approach procedures, including the design. This is where most CFIT accidents occur, and, of course, it led to the recommendations to try and make precision approaches more like -- or to make non-precision approaches more like precision approaches, where the accident rate is lower. It is the one most flight crews are performing most of the time. So, let's make non-precision approaches as similar as possible to precision approach.

The accident recordof decades shows that jet aircraft have crashed for failure to follow stabilized approach concepts. So, let's incorporate stabilized approach into non-precision, which means continuous descent powers rather than step-down approaches which are inherently unstable.

It is also, as I mentioned earlier, very easy to get out of step with those -- those particular vertical descents flying level going to another one and so on.

There's a recommendation, too, that the construction of such approaches should be around the three-degree point provided all obstacle clearance can be achieved, and that one should have a final descent power of at least eight to 10 miles to allow stabilized conditions to be established more easily than trying to do it from the final approach fix at four miles in-bound.

I'd like to just look at a chart at the moment, and this just shows a particular instrument approach chart. It's an ILS or a VOR to Runway 8 in Gabaroon or in Africa, and this is a particular approach with similar characteristics to Guam. This has a VOR DME at the final approach fix.

Down there in the bottom right-hand corner, if we can zoom in, bottom right, that's it, just there, you'll see DME distance with an altitude table, and this is the sort of information that a company I know which produces its own charts provides to pilots which gives additional DME guidance beyond that final approach fix to determine an optimum descent angle, and that actually computes to a 3.1 degree angle.

If we now go back to the profile, and we can see there in the middle the GBV VOR DME at the final approach fix, crossing altitude of 4,800 feet, there's nothing whatever to stop anybody commencing a final descent path instead of 5,300 shown some distance out. It only needs to be less than two miles outside that VOR DME to do a continuous descent path.

Indeed, you could run right around the whole procedure at 5,500 and face finals at 5,500 and commence descent at 2.5 miles before GBV and do a continuous descent all the way in. You've observed all of the limitations, but you have a more effective continuous descent and stabilized approach capability.

Now, this chart is not ideal, but that's the sort of thing that I would like to see us eventually rewrite such procedures using the aids available and to allow the pilot to operate the airplane in the best possible way.

If we now just look at the planned view of the chart itself, that's the upper half, again all I would just draw attention to are the colored areas there in light green, and the figures in there. These are minimum safe altitude contours. In other words, the figure you see there is a safe altitude to fly at.

Now that's one way of depicting contour presentation rather than the terrain itself. This is, after all, what the pilot wants to know. What's the safe altitude I can fly at? Not necessarily read the height of the ground, apply a margin, and then eventually get to the figure. This is prime presentation of information.

Next slide, please. Coming back to these applicable recommendations from the CFIT education and training aid, the next bullet here is altitude awareness, and here, it's important that the flight crew establish the applicable minimum safe altitude for where the airplane is going to be and where it is.

They also have to bear in mind that the minimum operating altitudes, when in low temperature or high winds, needs to be increased, and that, I think, is a correction that is not well understood worldwide for international operators who may occasionally operate to either very low temperature airfields or indeed may experience high winds when operating at low altitude.

Altitude awareness also includes the incorporation of the 500-foot radio altitude call-out, particularly on non-precision approaches. The value of such a call-out, if integrated into normal operations, is that it's in the vicinity of most minimum descent altitudes.

When 500 radio goes off, if you're not close to being visual with the runway, then you should be getting out of there. That's the intent of that particular call-out.

There's also a requirement here that there is rather more positive cross-check of the final approach fix crossing altitude before continuing the descent to the runway.

The next bullet is radio altimetry and call-outs. It is vital, the accident record shows, that we have improved terrain awareness. Most of our aircraft have the radio altimeter on board our aircraft, but many operators don't use it for normal operations and only require its use in Category 2 or 3 conditions.

The significance of that is that in Category 1 or even in VFR conditions, then one should have the radio altimeter as part of the instrument scan when below 2,500 feet and lower commencing the approach. The intent of it is to make pilots aware that they are getting close to terrain and need to be aware of it.

Another feature is that how do you integrate it? Do you have manual pilot call-outs or, better still, have automated call-outs through the ground proximity warning computer? That has a number of menus of call-outs, and many aircraft have them today. The value of automated call-outs is that it doesn't get tired, distracted or anything else. When crews can forget to make the manual call-out, the automation doesn't. But the important thing is to have procedures associated with it, not just to have the call-outs made and then ignored.

The next one down here is measurement and evaluation of system performance. The world's airlines have imperfect systems quite often to measure how their aircraft are being flown, whether the standard policies, procedures and so on are being observed, and to what standard.

Here, what I am recommending and what the Flight Safety Foundation recommends here is the adoption of flight operations quality assurance sorts of programs, the foci as we know in North America, and comparable programs elsewhere.

A growing number of airlines are now using such data which means analysis of either flight data recorders, quick access recorders, enhanced pilot reporting, whatever, to monitor how the aircraft are being flown, and that information can be used for routine engineering purposes or operational purposes.

Sticking with the latter, it is possible to determine if limitations have been exceeded, flat-limiting speeds, for instance, whether the aircraft had a rushed approach. In other words, mismanaged approach by the flight crew.

Another one is a recording of ground proximity warning system alerts. There is too little data being collected by most operators as to how ground proximity warning systems are working on their aircraft.

I think many of us know that accidents show that pilots were ignoring the ground proximity warning shouting at them when the accident occurred, and they were ignoring it.

The big question behind that is why? Now, we know that the false or nuisance activation of ground proximity for some systems can be high, but there are technical solutions to make them much more dependable, and therefore pilots should be encouraged to believe them.

But getting the data is half the problem. When you know the problem, you can then apply solutions. You can also see how flight crew responded to GPWS alerts. That, of course, has benefits in terms of having confidence that this safety system is protecting your aircraft, but also the technique that is being applied by the pilot in the recovery maneuver.

Again, that can be fed back into the training program to refine the technique, and then by gathering the data after the change, you can measure the improvement.

Another one is monitoring of go-arounds. We've talked a little bit about that earlier in this inquiry, and we believe it's important to monitor for a variety of reasons. Yes, we must not discourage pilots to perform go-arounds when necessary. Indeed, you must positively encourage them.

However, you need the data for these sorts of reasons. For instance, at congested airports these days, aircraft are being squeezed in to maximize capacity with minimum separation between airplanes. It is possible that by monitoring go-around rates, you may find a problem at one particular airfield. That may need a discussion with air traffic control to refine their procedures.

Another benefit could be not just the numbers of go-arounds but how are they performed. We all know that in the simulator on proficiency checks, pilots perform the required maneuvers well. They have to. They're being assessed on it, and nobody worries about doing aggressive go-around maneuvers in simulators.

However, most plots change when they've got 400 passengers sitting behind them on an aircraft, and there is almost an unconscious relaxation, an attempt to be somewhat smoother, gentler. The reality is you do a lazy go-around by comparison with an aggressive go-around, and when you are in the vicinity of low minimum descent altitudes or decision heights, getting close to the ground, you cannot afford that luxury.

So, again, if you monitor performance, you can feed this thing, feed the information back into the training and the education of your pilots.

The last one on here is the minimum safe altitude warning system. I won't go into any more detail on this, but there are recommendations about its worldwide application. It is available in many countries, as we've already heard, but it is in limited use worldwide. We need to see more of it.

You can take the slides off now, please. In conclusion, I don't have a slide for this but would just like to make a few remarks.

In spite of the efforts of the Flight Safety Foundation, the many individuals, some of whom are in this room today, and in spite of what we've now discovered about controlled flight into terrain accidents worldwide, they still continue to occur. Just ponder that. They still occur.

I believe that industry needs some degree of compulsion to take more effective action. It's not enough at the moment to have awareness and voluntary action. We need the help and support from the regulatory authorities to maintain the momentum of this Flight Safety Foundation initiative and the work that the industry has completed.

Remember the ICAO proposals that are being worked on now need state approval. State authorities will listen to their regulatory authorities. So, we need the support from the regulatory authority to ensure success of those ICAO proposals.

But that's not all. I believe all public transport operators should be required to have a CFIT avoidance strategy and a program with policies and procedures applicable to that particular operator and its operating environment, but based upon the Flight Safety Foundation education and training aid.

It's then not enough to have policies and procedures. The regulatory authorities must verify that they are in place and being used.

Operator training programs should incorporate the diverse nature and range of instrument approaches that they encounter in the real world in their simulators.

We should also recognize that continued development and application of new technology and equipment, both in the air and on the ground, should be positively encouraged.

Chairman, ladies and gentlemen, thank you for this presentation.

CHAIRMAN FRANCIS: Thank you very much, Paul.

I'd like to preempt perhaps a little bit a question, but -- but I think that this issue that -- that you mentioned several times of participation in the groups that are working on this and particularly participation by regulatory and air traffic authorities is extraordinarily important.

We basically have a situation where as far as I can see, the entire rest of the industry is involved, and yet the people who are essential to -- to moving much of the -- of the equation here that we're talking about are not involved, and I'd be interested in any thoughts you might have as to, Number 1, well, particularly why they may not be involved, and I certainly hope that this hearing and anything that we can do afterward to get them involved, we can all work on.

So, if you have any comments on this. We didn't co-conspire, by the way, on this, but -- but I think we're both coming from the same place.

THE WITNESS: Well, thank you, Chairman. Yes, it has been a difficult area. I think one recognizes that not just operators but regulators have also had difficulties with resources and processes of change and various other internal problems.

It has been difficult for them to resource these sorts of industry activities, but the converse of that is that we found it difficult, too, but felt it important enough to do it.

That, I think, is the -- the message that now needs to get to the regulators, that the work and the progress that has been made will not be maintained unless they join this program.

I know my own regulatory authority in the U.K. I have given presentations to them on this, and they have been reluctant to take it on as a regulatory activity.

Remember when I suggested that some encouragement be given to it. That's one thing, but verification means more work, and that maybe is what they're hesitating over. But I don't think we have the choice. The data shows that this is the biggest cause of fatalities, and we must react to it.

It would be a very powerful, I think, signal to the world if we could persuade, for instance, the FAA, either as a recommendation of this inquiry or beyond it, to come on site and to take a more active role in running with the recommendations that have come out of the Flight Safety Foundation.

There are no axes to grind here. We have a shared common goal, safety.

CHAIRMAN FRANCIS: My apologies to the Tec Panel for that, but I think that's an extraordinarily-important message for us to get across, and proceed.

DR. BRENNER: Thank you, Mr. Chairman.

You mentioned that there's been a -- a major reduction in CFIT accidents since the beginning of this effort. What -- what are some factors, do you think, in helping in that reduction so far?

THE WITNESS: I think the major factor has been the increased awareness within the industry, and certainly since the Flight Safety Foundation commenced this initiative, there has been a lot more media coverage of this activity.

The combination of this, I think, awareness and the growing availability now of products like the CFIT checklist, the various videos in both corporate aviation and that comes with the education and training aid, these are the sorts of things that are now being more widely applied within operators.

But I believe a great deal more needs to be done to maintain the limited improvement that we've seen thus far. We'd dearly like to see this problem eliminated.

DR. BRENNER: You mentioned the checklists, the CFIT checklist. How is that used?

THE WITNESS: The CFIT checklist, for those of you that may have seen it, is a fairly complicated list of factors which enables airline management, not operating flight crew members, but airline managements to assess the nature of their operation and to come out with a risk-degree factor at the end of it which may cause them to select appropriate measures that reduce that risk, various policies.

I mean, for instance, how one flies non-precision approaches or the use of the monitored or shared approach, those sorts of things. They are mitigating factors against a risk of a particular type.

So, yes, it's a management tool, not an operational tool.

DR. BRENNER: Would -- would pilots use it as well?

THE WITNESS: I don't believe they would find it very user-friendly, no. I think most pilots want things much shorter, sharper, punchier, whatever, and we already have difficulty with long checklists in airplanes now.

The CFIT checklist is quite complex and really is not a factor for them because most flight crew are not the determinants of operating policies and procedures. That's the airline management's.

CHAIRMAN FRANCIS: Excuse me, Malcolm. This is aimed -- the CFIT checklist is aimed at the issue that we're all talking more and more about, and that is that safety is not just the pilot ran the airplane into the water or into the mountain. Safety is ultimately the responsibility of corporate management in whatever company it is, and that this starts at the top of the management.

So, this checklist, while complex, is aimed at what the entire spectrum of the company is doing in terms of its policies in order to prevent CFIT. It's aimed at the company and not just at the operations people, but in the -- at the entire company.

THE WITNESS: If I might diverge very slightly, Chairman, there is some work going on in another country, which is trying to enhance what I would call awareness of safety management systems, and there, they have already discovered that the most important factor on the safety performance of any organization is its management culture.

Have the right management culture, safety in terms of both culture and performance will result. So, it's just really emphasizing the point that you made that safety starts from the top, doesn't stop there. It runs right down through the organization from top to bottom and all the way back up again. It has to be, you know, staffed. It has to be resourced. It has to have an organizational commitment to safety in everything that that management organization does.

DR. BRENNER: Captain, in the case of the accident flight, would the checklist have highlighted certain areas of risk that might have developed more attention?

THE WITNESS: I believe that the use of the checklist will highlight to management, yes, that certain types of operation do have higher risks and that there are policies and procedures that could reduce that risk when applied. But as I say, it is for managements and not the operating crew.

DR. BRENNER: The -- you mentioned that the CFIT training aid was sent out last year. How has the response been from the international community?

THE WITNESS: That is an interesting subject. We know that more than 2,000 copies of the education and training aid have been distributed worldwide through the manufacturers principally and through some training organizations and other industry bodies.

The difficult thing is we now have to gather data as to what airlines have done with it. We have no established communication at the present to measure that implementation progress.

So, the Flight Safety Foundation is considering sending out some form of small questionnaire, quite deliberately not aimed at where the CFIT education and training aid was sent. If it went to the VP, Flight Operations, and he did nothing with it, then it's no good sending the questionnaire to that particular individual.

What we'd like to do is to send the questionnaire to some lower point in the organization, for instance, into the training management arena, and also to the flight crew community themselves through the pilot associations.

We then have a measure of how effective changes might have been within the organization and the degree of communication on CFIT that's going on from top to bottom.

Now that data-gathering is due to commence later this year, and we will be eventually reporting on what we find to the Flight Safety Foundation, and we hope that that information can be used to both encourage the airlines that have started doing something and, I hope, to prompt those airlines that have done very little so far to start doing something quickly.

DR. BRENNER: How many airlines are using monitored approaches?

THE WITNESS: I don't have an exact number. All I can say is that there are a large number and a growing number now using the monitored approach, if not for all of their operations, at least for part of their operations.

The name of it may varyfrom one airline to another. I've already used the term "shared approach". Some airlines use the term "low-visibility procedures approach". So, they may have a different set of procedures for Category 2 and 3 that may be different to the procedures used for Category 1 or VFR flying.

There are also a number of military forces in the world that use it, too, particularly in the transport arena. So, yes, it's being more recognized and steadily growing.

DR. BRENNER: Among airlines that have hesitated to use this approach or decided not to or are considering it, what are some of the concerns that are raised?

THE WITNESS: There is a difficulty when an airline has an established operation that may have existed for many years, and pilots are resistant to change. It's remarkable how pilots can adapt to new concepts with a new airplane that they're required to fly but are remarkably resistant to changes of policies and procedures because they defend that which they know best.

So, airline managements whowish to make a change have a fairly uphill education task as well as a redefinition of policies and procedures to support the change.

It then doesn't happen overnight. I know from my own personal experience that it can take many years before these sorts of changes of concept can be fully accepted. But you only have to look at that accident data, and it's difficult to refute it.

There is a better way of flying airplanes. We know that. The data supports it.

DR. BRENNER: How many airlines have training for aggressive response to a GPWS warning?
THE WITNESS: Well, all airlines would claim to have it. I think only those airlines that have some form of system to measure performance in the way I was describing earlier know whether their pilots are actually doing it.
Simulator performance is not enough. You have to see what they're doing on the real airplane. I don't have figures of how many airlines are doing aggressive. I just know that that is the general policy, but few airlines have the means to ensure that it's being done.
DR. BRENNER: Yesterday, we spoke about considerations of tracking missed approach data. Do you have any -- any thoughts on that, on any value towards this type of effort?
THE WITNESS: I'm sorry. Could you redefine that question a little?
DR. BRENNER: I believe keeping airline records on go-arounds.
THE WITNESS: Oh, yes. We -- we keep the records. We feed the information back, and I think operators generally in being encouraged to keep the record should do that.

As I indicated, it does identify problem airfields with other causes for go-arounds, but the important thing is that we use it for beneficial purposes in terms of encouragement and also the correct performance of the go-around itself.

It is essential that the aggressive maneuver for a go-around is performed when at or near the minimum descent altitude or decision height, but when you are well away from it and commencing a go-around from more than a thousand feet away from such low altitudes, could be more gentle, and that may be an airline policy choice, but again have the data, use it, refine it, and then have confidence in how your pilots will perform.

DR. BRENNER: And we spoke yesterday about MSAW. Are there international standards or requirements?

THE WITNESS: There are none yet, and that is the work I referred to earlier in terms of ICAO. Have a proposal to mandate it at some point in the future.

However, we know that for recent radar equipment installed worldwide, most of them have the MSAW capability. Other than a few states, like North America, like Israel or Turkey or one or two other places in the world, most do not have them commissioned. They do not have them tailored to the installation.

Air traffic controllers are not trained in its use, and indeed there is some degree of air traffic resistance because, remember, MSAW, an alert, could indicate that the air traffic controller made a mistake, and there are some therefore cultural or punishment issues associated with that alert, which are natural inhibitors to adoption.

But all of those issues have to be worked through to make sure that we do have the safety benefit that is available but being unused. In other words, the cost of actually putting it in place is minimal. Let's use it.

DR. BRENNER: Is there CFIT prevention training for air traffic controllers?

THE WITNESS: There isn't, but there should be, and that was one of the recommendations that came out of the air traffic control procedures and ground equipment working group report, and the sort of things that need to be done are training to understand the capabilities and requirements of aircraft.

I think many of us take that for granted, but I believe air traffic controllers need to have more knowledge in that area. They need to understand the stabilized approach procedure and what it means to us as pilots when they ask us to fly at certain speeds to certain short distances from touchdown.

They need to improve their awareness of GPWS performance and radar vectoring in the vicinity of terrain. They also, I think, need to have education in terms of operation at low temperatures or high winds when operating at low altitude in the vicinity of terrain.

Many states have no procedures for such -- for such conditions. Others have procedures where air traffic control will modify clearances. Other states have procedures where they expect pilots to make the corrections and then notify air traffic of such corrections. There is no uniform standard, but there should be.

Those are the sorts of areas that I would see education needed.

DR. BRENNER: The NTSB has recommended to the FAA to make CFIT training mandatory for airline pilots, like wind shear -- training in wind shear avoidance. Is this a positive step?

THE WITNESS: That's a positive step, but as we have seen, and I -- as I have tried to reiterate, there is no single step that stops CFIT. It is a collection of measures.

CFIT education and mandating of it is just one element of those measures. Another piece of equipment on the airplane is not the only measure needed. It is a step in the right direction.

DR. BRENNER: Are there some measures that can be implemented immediately?

THE WITNESS: Well, interestingly, most of those things I talked about in terms of applicable areas of the Flight Safety Foundation education and training aid report, most of those areas could be applied at little or no cost.

What it requires is management will to do it, and then, of course, a resource and effort to support it. So, there is a small cost, but it's not a big one. We've already covered, I think, the crew education and awareness as being one step, but the most important thing is to make better use of the available equipment that we have on our aircraft. Some operators do that already, but many could make better use.

There needs to be a management review of policies and procedures. That takes time and effort, but it's well worth it. There needs to be appropriate and more effective training.

We also need to encourage, I think, the new equipment development and the application of new technology, and most important of all, we need to move in this area of performance monitoring so that we know how the aircraft and how the flight crew are performing when they're out in the airplane, not just in the simulator.

DR. BRENNER: Thank you, Captain Woodburn. That completes our questioning, Mr. Chairman.

CHAIRMAN FRANCIS: FAA?

MR. DONNER: Thank you, Mr. Chairman. We have no questions.

CHAIRMAN FRANCIS: NATCA?

MR. MOTE: Thank you, Mr. Chairman. No questions.

CHAIRMAN FRANCIS: Guam?

MR. DERVISH: Thank you. No questions.

CHAIRMAN FRANCIS: Korean Air?

CAPTAIN KIM: Thank you. No questions.

CHAIRMAN FRANCIS: Branson? Barton. I'm sorry.

MR. EDWARD MONTGOMERY: Thank you, Mr. Chairman. No questions.

CHAIRMAN FRANCIS: Boeing Company?

MR. DARCEY: Thank you, Mr. Chairman. No questions.

CHAIRMAN FRANCIS: KCAB?

MR. LEE: No questions. Thank you, Chairman.

CHAIRMAN FRANCIS: Mr. Feith?

MR. FEITH: Just several questions, follow-up questions, and the first one is probably tell-tale on ourselves.

You had spoken of the reluctance of regulatory authorities to become involved in this -- in this program, and you had spoken specifically of your regulatory authority.

Have you had any feedback as to the reluctance or a perceived reluctance on the part of the FAA or any other worldwide regulatory authority what their concerns are?

THE WITNESS: I've had no specific feedback to me personally at all. I have good contacts with my own regulatory authority, and they in principle support what's going on.

The problem is manpower to commit to doing it, bearing in mind all of the other tasks that they're supposed to be doing. That, I think, is more the heart of the problem, not an objection in principle, to what we're trying to achieve here, and it's a question, I think, of just changing priorities and recognizing that this is a valuable initiative that must be supported and continued to achieve the desired improvement.

MR. FEITH: I'll take that one step further and go beyond the regulatory authorities. I may be telling tale on ourselves, but has the NTSB or the AAIB or any other safety organization around the world been involved in this program?

THE WITNESS: Yes. I have to say that whereas CFIT may not have been supported as well as we would have liked, what I didn't describe to everyone here today was that the Flight Safety Foundation initiative concentrated on CFIT initially because of the fatality data that I showed you.

We also recognized that CFIT and approach and landing accidents are very closely related. Indeed, it's sometimes difficult to separate the two. It's really two sides of the same coin in some respects.

There are a number of working groups still running with the Flight Safety Foundation on the approach and landing accident reduction element of this initiative, and that has now involved both regulatory authorities and safety organizations, and I have to say I think that is after the event and the degree of success that CFIT activity showed. So, yes, we've got them involved at last.

MR. FEITH: And just to make sure that I have a correct perception, were the ATC authorities involved in the -- in this program, also?

THE WITNESS: They were invited to participate, and indeed the air traffic control and ground equipment working groups started off under an FAA chairman several years ago, but within a year, he took early retirement, and that was the end of FAA participation of any sort, unfortunately.

Subsequently, when the group was reconvened and then completed its report some 18 months or so ago, there were few representatives, if any representatives, from air traffic managements, but we actually had air traffic controller participation. So, it was the -- like the pilot, we had the man on the spot there.

MR. FEITH: So, that's worldwide air traffic control, --

THE WITNESS: Yes.

MR. FEITH: -- not just the FAA or --

THE WITNESS: Yes.

MR. FEITH: -- just --

THE WITNESS: That's correct.

MR. FEITH: -- that kind of organization?

THE WITNESS: Yes.

MR. FEITH: Just for a clarification, you had spoken in one of your presentations about stabilized approach velocity. I think just for the benefit, could you give us the nutshell or Reader's Digest version of what you mean by stabilized approach criteria for the approach segment because I think you related it to the three-degree approach?

THE WITNESS: I don't have the benefit of a diagram here, but if we can visualize a final approach segment around the three-degree descent path, and ideally one should have somewhere between eight to 10 miles of in-line approach, constant descent from what may be 2 to 3,000 feet, in a landing configuration established early enough such that the landing check-list can be completed and out of the way, to allow the flight crew to then perform the remainder of the final approach and the transition of the final approach fix without having distracting and conflicting tasks.

You then need to set gates at various points on the approach, and many operators choose, for instance, 1,000 feet above the field as a particular point when the airplane must be in the landing configuration, must be at the right speed at no more than maybe 20 knots past the target speed with the approach pass and landing checklist complete and so on, and that is the target for all approaches.

Then operators may have another point down the approach, and 500 feet is common, at which point there is a tighter gate still in terms of speed and associated conditions being on the vertical profile in the right position to complete the landing, and if the tighter set of conditions are not met, then there should be a mandatory go-around requirement from the 500-foot point.

The target at 1,000 feet, if not met, is one which has consideration given to go-around, yes or no; 500 feet mandatory go-around if the conditions are not met, and the final check is at 100 feet, and particularly on limiting runways, this target is where the aircraft has to be at the right point above the threshold, at the right rate of descent, and not exceeding a speed of, say, 15 or 20 as the maximum condition for landing.

On a limiting runway, if that particular gate is not met, then again mandatory go-around. So, I would liken it a bit like if you can imagine at 1,000, 500 and at 100 feet, three eyes of a needle. It's a slightly bigger hole at 1,000, a smaller home at 500 feet, and a very small hole at 100 feet, and you thread the aircraft through the needles, and you get it right.

MR. FEITH: Thank you, Captain, for that explanation. Appreciate it.

You had made a statement regarding providing all crew members with charts, so that they could basically all be up to speed on the approach. Would that include non-flying crew members; that is FEs or international relief pilots that may be in the cockpit but not actually performing a flying duty?

THE WITNESS: You added a caveat on the end there, not performing a flying duty. There are some two-crew aircraft designed for two-crew operations which have third crew members which do not have assigned duties, and that is one category, and I would say in that case, it's the operating crew members that have to have the charts.

However, there are many three-crew aircraft operating in the world today with either flight engineers as pilot or engineer in the third seat who are forward-facing for take-off and landing and who do have assigned duties of monitoring the pilots.

If they are to monitor effectively, they have to have the chart to be able to do that. It's very difficult in night-time conditions to be looking over a pilot's shoulder trying to reach his chart when you're supposed to be doing other things as well, or during briefing to try and extract and write down relevant bits of information to enable the monitoring to take place. That -- that procedure, I think, is unsatisfactory.

MR. FEITH: And with regard to one of the charts that you showed depicting minimum safe altitudes and your explanation that pilots would rather see what the minimum safe altitude is than to try to figure it out, ball park it and then make sure that they hit the right altitude, the chart that you showed is produced by an independent organization over in your side of the world. Jeppesen, of course, is typically a world standard for charting.

Do you have any comparison because Jeppesen doesn't show that on their charts? Do you have any particular opinion about the differences in charting?

THE WITNESS: Yes, I do. I mean I'm not being critical of any particular company. I believe that the industry recognizes that terrain or minimum safe altitude are better presented in contours rather than in tabular or spot height form.

One gets a much better impression. I actually have two charts here to show a comparison of the two different techniques which I could show, if you would allow me.

MR. FEITH: Please.

THE WITNESS: And you can see therefore the difference of presentation that one should, I -- I emphasize, not be critical of either. They are satisfying two different purposes, and the rationale behind it is to make it easy to read and use.

Now both are better than the ways that used to be the norm, and I would encourage developments in this direction. The problem, of course, with minimum safe altitude compared with presentation of terrain is that you may need some degree of skill and cartographic application to, as it were, draw the right minimum safe altitudes versus terrain which is fixed to the ground or topographical charts. You may simplify those, but they're easier to draw.

So, let me just show you, and you can see what they look like.

MR. FEITH: And just for the benefit of us, we're going to give Jim Terpstra an opportunity to defend his position when -- when he testifies regarding Jep charting.

THE WITNESS: What you've got here are two real charts.

MR. FEITH: Excuse me one second. Can we just lower the lights a little bit so we get a better picture, please?

THE WITNESS: Is it possible toocfus that slightly differently? Okay.

Here on the left-hand chart, this is minimum safe altitude presentation of the safe altitudes to fly at, and you can see, I think, pretty quickly that it's very easy to pick the appropriate figures here. They're in hundreds. The large digit is the thousands, the smaller digit being hundreds, and it's very easy to then -- this -- these are the mountains to the southeast of Geneva.

If we look at the -- the chart on the right-hand side, here we're seeing -- if we go to the same area, the bottom right, one has to be a little bit more careful in terms of reading the figures on here and remember this is terrain. So, you've got to get the right figure, then apply the right margin of either 1,000 or 2,000 feet obstacle clearance, and remember you've got to do this in night-time cockpit conditions with the airplane flying at various speeds.

Now both of these presentations, this one is in a brown tint which shows the ground, the other chart is showing minimum safe altitude, which is in green, these conform with the ICAO Annex 4 requirements for charting, which says that the ground shall be in either black or brown, and that minimum safe altitude shall be in green.

Now, obviously one can see the basic similarity of terrain is evident on both, but you have to ask yourselves which is the easier one to use and apply flying an instrument approach.

We, in my particular company, started off using the terrain contour presentation some 35 years ago, and we then found some difficulties of interpretation in the night-time configurations of those aircraft.

We started to experiment with this type of minimum safe altitude display, and in the 1960s ran a test with our pilots, and we had a more than 90 percent in favor of presentation of minimum safe altitude rather than the terrain itself, and for the past 30 years or so, we have maintained this style of presentation.

Either of these, as I continue to reiterate, is much better than those earlier charts which did not have the contour presentation on at all. So, the fact that the industry is now moving in this direction is, I think, enormously important.

MR. FEITH: Thank you, Captain.

Lights up, please. One last question. You had talked about trying to collect, I guess, real world data from line operations, so that you could feed that back into the training arena, and I think you as a line pilot know, and I think the industry knows, that a lot of times, the collection of such data is feared by pilots, that management will use that for other purposes other than for training or education but more for punitive action.

Given that we are trying to collect real world data, we're using crew performance data as an educational tool or that's the intent of it, how do you change that mindset in the crew, in the cockpit, that this won't be used as a punitive tool, it's used as an educational tool because that fear goes very far back, especially with the use of the CVR or the flight data recorder information, things like that?

THE WITNESS: That is a complex issue. You really need to have an agreed set of procedures between an airline management and its flight crew community. It also needs the positive support of the associated regulatory authority, such that punishment doesn't follow from such data. That should not be the intent.

I think all pilot associations know of the various schemes in existence whereby such data is collected on an anonymous basis. It is not associated with a particular pilot, and some operators have procedures whereby only the union representative can be given information from engineering, not flight crew management, to eventually contact an individual to seek further information.

Airline managements do not have access or should not have access to the individual themselves, except through pre-arranged procedures that the pilot associations are comfortable with.

I know of many operators who've moved in this direction, and, yes, it is a learning process, an education process, and it's not enough for managements to say certain things. They actually have to do certain things. They have to prove and support the agreements, and they must not hound the pilot to punish him because they prejudice the whole system and the value of the system.

So, it can be done, but it needs positive education, support, appropriate procedures, and then the support of the regulatory authority to make it work.

MR. FEITH: Captain, thank you very much for your testimony. Appreciate it.

CHAIRMAN FRANCIS: This last issue is -- is a question of establishment and maintenance of trust and confidence.

Pat? Mr. Berman?

MR. BERMAN: Captain, we heard testimony yesterday from Korean Air about their procedures for responding to a GPWS alert. We heard that there is not a mandatory go-around for a sink rate or terrain -- terrain warning in IMC.

Can you please evaluate that procedure?

THE WITNESS: There are, I think, two levels of alert from ground proximity. There is, as we all know, the pull-up alert associated for most airplanes with red warnings and that is and must be a mandatory go-around.

However, there are other what we would call secondary alerts, which many operators allow their pilots to correct the condition without necessarily associating it with a mandatory go-around, unless they are at a low altitude, and the secondary alert is continuous, and the best course of action is therefore to get out of there.

Many of the secondary alert features of ground proximity warning with -- if they exist for a period of time, get translated into a primary alert of a pull-up anyway. You'll get there.

MR. BERMAN: Could you give me an estimate of the number of air carriers that you are aware of that -- that do not have that procedure? In other words, that require a mandatory pull-up for a secondary alert, such as that.

THE WITNESS: I -- to be honest, I have no data on that. I know what a number of airlines do, which is what I've described. I know what manufacturers and the -- both of the airplane and the equipment generally recommend that we do, but beyond that, I have no figures on it.

MR. BERMAN: Okay. Thank you. What has been the usage worldwide as far as you know of the Flight Safety Foundation CFIT training aid?

THE WITNESS: I believe the use has been extremely limited worldwide. I think a number of airlines are still in the process of translating what is a fairly large package of material into something that suits their particular operation.

For those of you that have not seen the education and training aid, it is two very large volumes of paper with an associated video of some -- some 30 minutes' duration, and it is not an effective package to give to pilots.

You have to, I think, take appropriate elements out of that, repackage it in a form that is then suitable for individual flight crew communities. That takes time, and my belief is a number of operators are in that phase of adapting it. Many others, however, I believe, are still in the phase of it got parked on a shelf somewhere gathering dust, and it has not yet received serious consideration within those operators, and that's why I feel that the efforts made by the Flight Safety Foundation to find out what happened to this distribution of the aid will be valuable because it will be another reminder to that package that came last year how we should have done something with it, and it will spur them into action, I hope.

MR. BERMAN: Thank you. Could you please characterize the workload involved in executing a constant rate descent procedure on a non-precision approach without an electronic glide scope and without pre-calculated descent starting point or -- or pre-calculated check points along the way that are on the chart?

THE WITNESS: If you have no means of establishing additional data points on the final approach, the constant descent without other than just a final approach fix requires the calculation of an estimated rate of descent based upon ground speed for the final approach segment, and associated with the constant angle approach is also the need to be stabilized at an early enough point such that landing checklist is out of the way early enough, flight crew can positively then monitor the conduct of final approach.

The workload of such a procedure, I think, is considerably less than attempting to fly level, for instance, a descent to an MDA in a jet aircraft that's 3 or 400 feet above the field typically in a landing configuration requires fine judgment to then seek visual reference over a nose pointing in the air and then complete an approach at the right descent path to the runway, all of that in limiting conditions.

The constant angle descent, I believe, also should be associated with a philosophy of not flying level and on reaching an MDA, whatever that value is, if visual reference is not secured for landing, then the aircraft should conduct a missed approach at that point.

MR. BERMAN: Captain, if pilots were executing a constant rate descent-type approach, would you expect them to set into the altitude selector the intervening step-down altitudes?

THE WITNESS: I would believe that that is one way of doing it, yes. My particular aircraft is well-endowed with flight management system constraints, so we can achieve that, and those restrictions will be observed.

For a more basic aircraft, yes, that can be done. It can also -- one needs to be careful of observing limitations without setting those in. If you've got effective pilot monitoring, that can be done, but it is safer to put those intervening altitudes in so you have the protection that the airplane should level off, particularly if operating under autopilot.

Even when operating with flight director, there are commands on the flight director bars that if the pilot inadvertently continued descent when he should not have done, then he gets the protection of those intervening altitudes being set, yes.

MR. BERMAN: Okay. Thank you. No further questions.

CHAIRMAN FRANCIS: Mr. Schleede?

MR. SCHLEEDE: Yes, just one short question about your comments about the need for both flying pilots or two pilots having sets of charts.

Do your comments apply also for smaller aircraft, like twin -- small commuter airplanes?

THE WITNESS: Yes. In fact, it's less of a problem with the bigger operators, and it's much more of a problem with the smaller operators where, for a variety of reasons, probably cost, one set of charts tends to be supplied, and where two pilots are carried, they share charts. That's commonly the case.

MR. SCHLEEDE: Thank you.

CHAIRMAN FRANCIS: Thank you verymuch, Captain Woodburn. That was very, very helpful for us.

THE WITNESS: Thank you, Chairman, and ladies and gentlemen.

(Whereupon, the witness was excused.)

CHAIRMAN FRANCIS: We'll now take a break. It is, according to my watch, seven seconds before 11:00. We'll come back at 20 after 11.

(Whereupon, a recess was taken.)

CHAIRMAN FRANCIS: We are ready to go. Our next witness is Mr. Don Bateman, who is Chief Engineer, Flight Safety Systems for Allied Signal, also a participant in the CFIT activities of the Flight Safety Foundation, and I believe he's been sworn in by Mr. Schleede, and Mr. Schleede has the floor.

Whereupon,

DON BATEMAN

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

TESTIMONY OF DON BATEMAN

CHIEF ENGINEER, FLIGHT SAFETY SYSTEMS

ALLIED SIGNAL, INC.

REDMOND, WASHINGTON

MR. SCHLEEDE: Thank you. Mr. Bateman, give us your full name and business address for the record.

THE WITNESS: My full name is Charles Donald Bateman. I'm known by my friends as Don. And my address is in Redmond, Washington, the State of Washington, at Allied Signal Company.

MR. SCHLEEDE: Thank you. Would you give us a brief summary of your education and experience that qualifies you for your current position?

THE WITNESS: Well, I like flying. I was -- I graduated from the University of Saskatchewan as an engineer, electrical engineer, and then I worked back East for a heavy radar company, and then I went to work for a very informative two years at Boeing on the 707 and left there, and I've been with the same firm, even though we've been bought twice, since, and our kind of business was -- was avionics, designing equipment for aircraft.

MR. SCHLEEDE: Thank you very much.

Mr. Pereira will begin.

MR. PEREIRA: Good morning, Mr. Bateman. How long have you been working on CFIT prevention, and in what capacity?

THE WITNESS: Well, in about 1966, I was a Caravelle flown in short at night, drizzle, in Ankara, Turkey, and it was operated by SAS, and -- and everyone had lost their lives in that accident, and it was a lot of concern about maybe this could happen again, and Scandinavian Airlines wrote sort of a problem statement that it shared with the industry.

What they really wanted was basically a system that would be like a fire-warning bell that would inform the pilot that something was wrong, and that's how we started out in the evolution of -- of a warning system that we call Ground Proximity Warning System today. So, that's 31 years.

MR. PEREIRA: Okay. There's been a great deal of discussion about GPWS and enhanced GPWS at this hearing. As one of the primary manufacturers of these systems, would you please describe what GPWS and enhanced GPWS are, taking time to explain any of their relative advantages and disadvantages?

THE WITNESS: All right. I'll try to do that, and I'll try to keep it short. I brought some view foils or overheads that perhaps will make the points I'd like to make.

The purpose of what we call ground proximity warning systems or GPWS, as the acronym, is to provide the pilot with a timely alert, visually and orally, of possibly flying into the ground or water, and at that time in '67, in 1967, we really wanted to use what's on the airplane. We -- at that time, our Category 2 equipment was being installed, and as part of that equipment was the radio altimeter that looks down below the airplane to see the terrain.

We also had air data signals, and we also had glide scope deviation which exists on just about all the airplanes. So, that's basically the purpose, was to provide an early alert, if possible, something could be wrong.

Next slide, please. Since that time, we've accumulated in the 31 years a tremendous amount of experience. Today's commercial jet airfleet is about 12,500 aircraft, and, unfortunately, we still have airplanes being flown with no ground proximity warning system nor -- in many of them nor radio altimeter. But, nevertheless, it's a very high proportion of the airplanes are equipped and flying with some form of ground proximity warning system. Some are very old and ancient and some are pretty new.

We've accumulated over 230 million departures probably worldwide. So, there's a lot of experience with this equipment, and in conjunction with minimum safe altitude warning system in the United States, because that really is very, very effective technology -- pieces of technology can reduce the risk, and we've lowered it from about .85 to .03 per million. That's a 28 times reduction in risk, which is paid in terms of airplanes that have been prevented from flying into the ground.

Unfortunately, in FAR 129, it still remains high, and -- and the previous speaker, I think, made some very good points about why we must continue with training and so on.

Next slide. What the GPWS uses is the existing radio altimeter, and looking at the radio altitude, the height above the field, we look at the descent rate. We also can use air speed sometimes to try to advance the alert, if a high-speed descent or flight is involved.

We try to look at the landing gear, not to determine really that it's down or up, but just to determine that you wouldn't be where you are with, say, 500 foot of terrain clearance with the landing gear still up. Something's got to be wrong. So, we try to alert the pilot.

The same with landing flap. Most pilots try to land with the landing flap as part of the procedures. If it's not down, the terrain clearance may be as low as 200 feet, something's wrong.

We also normaly don't fly the airplane below the glide scope. So, we use that in conjunction with relating that to the ground to alert the pilot to the fact that something may be wrong with the glide scope or his position with the respective glide scope.

In some installations, we use a radio altitude setting, whatever the pilot has put in, to use it as an advisory or an alert for the pilot.

Next slide. The outputs we get from the GPWS are soft alerts, sink rate, and I believe in this particular -- at Guam, we heard one sink rate. Down sink would be at take-off when the airplane may be in the dark accelerating back into the ground. We also get too low terrain, glide scope, that sort of thing.

A hard warning is when we've got to a point where we're running out of time to recover the airplane. Typically, we say terrain, pull-up, and the pull-up -- at first, when we start out with GPWS, it was a warning tone because we couldn't -- technology was such that we couldn't generate a voice, but we've been able to generate many voices now. Maybe we've got too many of them.

Advisories. We'd like to also from the radio altitude altimeter create a list of advisories. The flight operations people usually select these. I believe on the Guam -- Guam -- particular Guam airplane involved at Guam, we heard a call-out at 1,000 feet, at 500 feet, and a hundred, so on, as we approach over the runway.

GPWS, like anything in this world, has got its limitations, and it has -- the limitations have been rather illuminated for us, and in this particular accident, they're illuminated again. It can give very short warnings for flight into precipitous terrain. That's what happened, I'd say, in some of the recent accidents, like Cali. There just wasn't enough sufficient time for the pilot to recover the aircraft.

We -- we may not give an alert or warning for a stabilized approach or stable flight into the terrain when you're configured for full landing. GPWS has no way of knowing where the end of the field is or the end of the -- the runway, and if there's no glide scope signal, there would be no glide scope alert, and another limitation, the last one I put there, is the altitude calls are referenced to altitude above ground, not runway, and we have some differences sometimes.

GPWS is required -- I think that's the wrong one. Sorry. Let me just read from this anyway. A misplaced slide here. Could you excuse me just for a moment?

(Pause)

THE WITNESS: Sorry. I -- my slides got misplaced. In the United States, GPWS is required on all U.S. airplanes with 10 passenger seats or more, and that -- and these -- these aircraft operate under Part 121, 125 and 135.

GPWS is not required for foreign aircraft in -- flying in or out of the United States under Part 129. However, under ICAO, Annex 6, most states are recommended -- recommended to carry an operating GPWS, and most states, including South Korea, do comply.

In the last 12 years in the United States and for operations in and out of the United States possessions, I put a list on here. There's 12 airplanes, and as the previous speaker and other speakers have said, this is an on-going problem. Agana is only one of these 12, and -- and the operator is -- is not specifically isolated. There are many, many operators involved with these losses. Many countries. It's a worldwide problem.

The Agana fits in the -- in the situation where the airplane's configured for a landing, and there's no warning. There were advisories, and I don't understand why the crew flew through those advisories.

Lima, Peru, was an American airplane, a cargo airplane, a non-precision approach in 1996. Cali, we've mentioned. You can go through each one of these, and, unfortunately, most of them involve a loss of life.

In San Salvador, we lost two ambassadors, the ambassador from Holland, from the Netherlands, the ambassador from Brazil, and in La Paz, Bolivia, which is at the very bottom there, an Eastern Airline airplane, we lost the ambassador to Paraguay's wife and the director of the Peace Corps. These are very painful to the people involved.

Next one. Last year, just to show that it's a worldwide problem, we lost three airplanes. Agana we're talking about today. Madan, Indonesia, was a radar vector for an ILS and a miscommunication between the crews, between the controller and the pilots. At Bangladesh, we had an F-28 that went in in landing configuration into a rice field in the dark. Unfortunately, the airplane was destroyed. Amazingly, nobody was killed.

Next one. This one right there.All right. If you take these 12 accidents, you can put them down here in a -- sort of a breakdown. In many cases, not in the U.S. but we have had worldwide no GPWS installed. A very small minority of airplanes is where the greatest risk is in the losses, and then we've had the 28 percent shown there with no warning. This is a case where the airplane -- aircraft is configured to land and no warning.

These late warnings or improper pilot response for the 41 percent would be what I would classify like Cali, there just is not enough time by looking down to try to see ahead.

Let me go to this one here. Put this up. So, we've tried to improve the GPWS by providing increased situation awareness, if we can, of significant terrain or obstacles with relationship to the aircraft.

If a pilot can really perceive where he or she is with the relationship to the runway or the terrain, we've got a much better chance of never ever having an alert or a warning in the first place. We'd like to by looking ahead into that terrain database, if possible, provide a timely alert that is more in the nature of about a minute or half a minute compared to the 15, 10, 12 seconds we get now with the conventional GPWS.

Again, we also want to keep the system practical by using existing sensors, such as the FMS, IRS or INS, GPS, scope of positioning system; that is, in -- it's on the existing airplanes. We also want to use an existing weather radar or EFIS map display to show the terrain.

We use the same signals as GPWS. eWuse position data that's already in most of the airplanes, that's already wired to the GPWS. We have track and heading and ground speed from those signals. We use altitude MSL because quite often -- I mean in the databases which I'll talk about this morning. They're measured -- they're referenced to mean sea level.

A new signal, though, we do need is the display range, and the output as shown at the bottom is -- we want to drive the EFIS or weather radar with terrain pictures.

And we want to add -- to make this thing work, we need to add the worldwide database, which would be airport terrain, airport runway ends, the terrain data and manmade obstacles.

A wonderful thing happened during the end of the Cold War between the Western powers and the Soviet Union, was that both -- enlightened people on both sides decided to use the digitized terrain that was developed for military purposes for cruise missiles and so on be made available for the civil sector, and that's been very, very good. It is something I didn't think would happen in my lifetime.

The second thing I didn't think would happen is we would be able to develop flash memory, memory on the consumer side, very low cost but very small size, that we could store this data on, and typically we can put that -- all that data on the size of this credit card, and this -- this is -- this has all been happening in the last five years. Something that we dreamed of but never realized it would really happen so quickly, all of a sudden.

We need also, though -- one point I want to make out, is that some of the countries in the world still consider their terrain data as military, classified, and -- and Korea is one of those, unfortunately. We need Korea and many, many countries to share that data with the world, and it doesn't have to be down to military quality data, but it can be down to about what we call 30 r seconds or half nautical mile cells. This is good enough for what we need for commercial transport purposes.

And I should skip this slide, buthis looks awful busy, but the portion that's shown in green, those all exist in most airplanes. All production airplanes don't have all those signals that go to the GPWS. So, we're adding the bottom there, which is a blue section, which is basically the terrain databases and airport data, and then we want to drive a display that -- that we share with either showing weather radar or terrain.

A quick view, next slide, please, shows -- this is typically like the size of a chocolate box. It's -- and -- and from the front, we can load data which we don't have to do. Terrain doesn't change very much in our lifetime. So, it's a very reasonable thing to do.

But the idea is to use what is available in the airplane and replace -- simply replace the existing GPWS computer with the enhanced one.

Next view foil. This is a picture of my colleague, Hans Mueller, and we're looking at a terrain in a -- on the right there of -- we're at Juneau. We're in a 747-400 airplane which is rather unlikely to be at Juneau, Alaska, but, anyway, we can see the plan of departure's down that canal, and we should always have a black area where we're flying.

To make the display intuitive, next view foil, we use a scheme of the terrain that's referenced to the airplane. This is not a map of terrain. This is a -- is terrain that's referenced to the airplane. You're flying at 30,000 feet. It will be all dark shown on the very bottom there. If you get within 2,000 of the -- of the terrain, we start to have a slight color of green, and as we approach up to the altitude, it should be still a little bit green. It will start to go yellow and above there, more yellow, and finally we get to a dotted density of red.

How that looks in the next view foil. Attorneys won't like this, but I picked Cali. This -- if you were -- the airport is -- is at the top of the screen there, SKLC, and we're at Tulo, which is a sort of initial approach fix.

At this point, this is what a normal approach you would see. You'd see all the dark. It's all dark, and the terrain is red, at least 2,000 feet above you or more, and the yellow's a thousand feet above you, less yellow is at your altitude or higher, and you can get a good picture, sort of a situation awareness, that everything's okay here, and the planned flight path as shown on the display is correct.

We want to also look ahead into the terrain database and to give an alert, and this looks rather complex, but it's -- it's -- it's below the airplane. There's two envelopes. One is a cautionary alert, one's a warning. They vary automatically with your speed and your relationship to the airport, and we also want to make sure that we can out-climb the terrain. So, we also look up six degrees. As one of the witnesses told you that day in MSAW, it was five degrees.

Next slide. And this is sort of a crude picture, but you can see the airplane flying towards these terrain cells, and these terrain cells are about a half a nautical mile each, and when the elevation is stored above sea level.

The -- also, we want to surround the airport with a terrain clearance floor. The bottom of this bow is the airport, and we store in terms of information the ends of the runway, and then we slowly build a floor up that progressively grows with distance from the runway to try to protect against landing short. As the previous speaker said, half of our losses are on the non-precision approach.

This is a picture of what would -- of the track that you've seen that the NTSB has displayed as shown. The airport is at the extreme right, in the upper corner, right corner. This is a ground track picture.

These are the terrain cells, and in each of those cells, you will see an elevation stored digitally on some flash memory.

Please change.

MR. PEREIRA: Mr. Bateman, before we go too much further on to the Korean accident, could you touch back again on the database, the terrain database? You mentioned that Korea hasn't provided it. Is there a significant lack of worldwide coverage or could you summarize that briefly?

THE WITNESS: The -- the -- some countries still consider it a military secret. Basically in South America is a prime example of that.

The United States is in the position of releasing much more data, but we're very, very sensitive to political and military agreements with some of these countries. So, we've had to work as a company trying to acquire data any way we could, and the Russians have been very supportive in trying to do that for us because they're willing to -- they need money, and -- but some places still missing are the bulls in Brazil, the upper latitudes agreement.

But essentially we have most train data today, but not to the accuracies we'd like to have.

MR. PEREIRA: Do you have a map of the world that shows that coverage or --

THE WITNESS: Well, I apologize to everyone in this room that I did that terrible, terrible thing. I didn't match my view foils to the -- I thought we were.

Yes, as shown in blue areas what we're still missing, and you can see little bits of every country except the United States and Canada is very thorough, but most of the airports of the world that we're operating in, too, like Agana, is -- was covered.

Agana wasn't an original -- what we call a digital or a DMA release from the U.S. Government, but we -- we generate it ourselves before the accident and had it in place. So, we have some work to do in the blue areas there.

Korea is not shown as blue but it's basically very crude data, and -- and as I said, Russians have helped with -- helped us with some data for -- I see North Korea is filled in.

MR. PEREIRA: The large South American area, what's preventing us from getting that data?

THE WITNESS: Well, as I said, these governments, like Brazil, have border disputes with -- with Peru, Ecuador, not so much with Ecuador, but certainly with Colombia and Venezuela and -- and -- and Bolivia, and -- and it's difficult to get military to release anything less than 500,000.

In the United States, we have much -- we can -- our military probably has much of this data, but they certainly don't want to offend any particular country. So, we've had to assemble this.

In the Brazilian area there, you'll see some areas that are not covered. We've added those ourselves at great expense from satellites to be able to put terrain around key airports.

MR. PEREIRA: Have you exhausted all -- all of the possibilities with the U.S. Department of Defense on obtaining these data?

THE WITNESS: No. After the accident, after Brovnik and the White House, I think, we became very interested in -- in controlled flight into terrain. They've been slowly applying pressure on the -- on the military and the State Department to try to work out something reasonable with the different states involved, and I'm hoping, I'm very optimistic that more and more data will be released.

This isn't just data for our particular kind of instrument, but it's very important. It can be very, very useful for people who design instrument procedures, engine-out procedures, things like that. It's a great safety tool for us.

MR. PEREIRA: Is there anything in particular that you think the Safety Board could do to assist in getting these data?

THE WITNESS: I think just be supportive of efforts by FAA and NOAA and our military, too, and -- and -- and -- and with the State Department the best we can to try to get the individual countries involved to help.

MR. PEREIRA: For enhanced ground blocks, are there any future regulatory plans that are in the works?

THE WITNESS: I understand there's a notice of proposed rulemaking that has -- that I was briefed last week on this by an FAA person publicly, that will be called a notice of proposed rulemaking, has been generated requiring upgrading GPWS to enhanced GPWS, also lowering it down from 10 seats to six seats in the United States. This has been signed by the FAA Administrator Jane Garvey and has gone to the Department of Transportation for review and hopefully soon being published for the public to comment on.

CHAIRMAN FRANCIS: Can I ask a question here, Don? Is -- is there, in addition to the number of seats, also a -- a requirement that would affect large cargo aircraft?

THE WITNESS: I think the NPRM, as I understand it, will cover all Part 121 operations, and -- but -- and, so, it would cover the cargo aircraft.

MR. PEREIRA: Did they mention any proposed dates for implementation of the requirements?

THE WITNESS: Well, I think their target is something like 2003 to have all aircraft fitted. An interesting thing has happened, is that all the airlines, major airlines in the United States, through their collective industry representative called Air Transport Association, has made the announcement that they were going to equip these things voluntarily with no rule, and they will all be completed by 2003.

We've already sold -- I'm not a sales person, but as an engineer, I've been really baffled. We have orders for over 4,600 aircraft in hand, and by the end of this year, we will have delivered a thousand or over a -- we've delivered over a thousand this year. There will be over a thousand airplanes fitted in basically the United States by the end of this year out of about 4,300, I think it is.

MR. PEREIRA: Okay. Why don't we get back to the Korean Air 801? What kind of GPWS was it equipped with?

THE WITNESS: Well, that's going -- I'll show that in a couple of view foils. Let me finish this one picture of enhanced, and then we'll go back and look at the --

MR. PEREIRA: Okay.

THE WITNESS: The next one we have here. This is a profile as you show on the wall, and this is the terrain along the flight path as shown in these individual terrain cells, and you can see that we would have given an alert or warning or the first alert much like the MSAW system, is about almost a minute. In this case, it's about 50 seconds.

What it would tell the crew, it would show a picture, bright yellow, something's wrong. I'll show what that looks like, and it would say orally on an automated voice call-out, Caution, Terrain, and Caution, Terrain, and then it would repeat itself.

In this case, it would have heard Caution, Terrain, Caution, Terrain, and then seven seconds later, we would have heard Caution, Terrain, Caution, Terrain again. That would have been followed by a red set of cells which I'll show you with the oral voice saying Terrain, Terrain, Pull Up, and the pull up would have continued for 43 seconds or so to impact.

MR. PEREIRA: Don, where did you get the data for that graph?

THE WITNESS: From yourself.

MR. PEREIRA: Okay. And it's based on FDR data and the terrain data off the Agana map, is that correct?

THE WITNESS: Yes, sir. The cells along the bottom are what -- from the ground track that you had portrayed.

MR. PEREIRA: And you said the two warning times are -- are what, again?

THE WITNESS: They're 52 seconds is the caution before impact, which is considerably better than we could ever do with most ground proximity warning system times, and then 43 seconds, hard warning, until impact.

MR. PEREIRA: And --

THE WITNESS: Hard warning being Terrain, Terrain, Pull Up.

MR. PEREIRA: And what would the automated call-outs have been at those points?

THE WITNESS: Automated call-outs?

MR. PEREIRA: Or the oral alerts. What -- could you describe those at those points?

THE WITNESS: Yes. The oral alert is Caution, Terrain, Caution, Terrain, and then the hard warning is -- what we call hard warning is Terrain, Terrain, Pull Up, much like the existing GPWS.

MR. PEREIRA: Thank you.

THE WITNESS: The picture I can show you from existing terrain data would look something like this, and I'm sorry, in the projection system, it really doesn't show that well, but the screen is black, except for the colored area, the high ground of Guam, and you see a touch of yellow in the left-hand corner, and as the airplane's progressing down, the green would be -- indicate it's relatively safe, it's be careful, though, because the terrain is being shown.

Most airports, there would be very little shown here that the terrain is not -- the terrain is not a significant factor.

Next view. Next one. The next view foil is about -- as the -- as a profile or the aircraft descends further and further and further. We still don't see very much change.

The next one, please. At the 53 seconds from impact, we would hear this oral Caution, Terrain, and the screen would go a solid yellow indicating that something's wrong with the flight path. It's too low, there's terrain, something is wrong. This is something we would normally ever see in normal operation, and as we continue on, the next -- with the -- we continue our descent further and further.

Next one. We actually get the red -- solid red alert, which is Terrain, Pull Up, Terrain, Pull Up, and as you can see for both the Cali and this particular incident, if you had actually seen a display, and the display is up and operating, you probably wouldn't have done -- you would have probably, even before you got the alert, avoided the situation developing.

MR. PEREIRA: Don, is this the screen that would have showed up at approximately 47 seconds prior to impact?

THE WITNESS: Yes.

MR. PEREIRA: Okay.

THE WITNESS: This screen we're looking at would be like an existing color weather radar screen or an EFIS, which is like a map display in front of each pilot. Those exist in most airplanes today.

MR. PEREIRA: And this would show up on his screen without requiring any pilot action for selecting the system?

THE WITNESS: Most installations, the -- this display pops up automatically and without any pilot input. The pilot can select the terrain at any time, and -- and as I said, one of the new signal goals of EGPWS is the range the pilot has selected. So, the terrain will be automatically scaled correctly for the display involved.

Right now, -- thank you. Right now, this slide is out of date, but this was the beginning of the year. We have over 300 airplanes, jet airplanes now flying worldwide. British Airways was the first one to put it on a 747-400 over three years ago, and -- and every day, the fleets are being rapidly fitted.

American Airlines is one that's got a very, very brisk program followed by United, followed by Delta, followed by just about every airline in the

United States.

Foreign operators are Lufthansa, British Airways in itself is going to fit their whole fleet, and the number of certifications, which is probably the most pacing thing we have, the base pacing thing is by the FAA, and they're trying to streamline things, and I hope that they can do, but we're over about 20 now certifications. We need to get to about 250 different airplane types and variations on that, and as I said earlier, the intent by the airlines themselves is to be fitted with -- with no mandate, is to be fitted by the year 2003, and as I said, we have -- we have no trouble getting convincing airlines to put this kind of equipment on their airplane.

MR. PEREIRA: Mr. Bateman, was Enhanced GPWS available for Boeing 747s at the time of this accident?

THE WITNESS: It was available for airplanes that were in production, like the 747-400. As I said, British Airways had one, 757-767, on the retrofit basis, but it was not available as a unit for replacing, directly replacing the 737-300 unit which was a Mark-7, and --

CHAIRMAN FRANCIS: Excuse me. 747-300 you're talking about?

THE WITNESS: Yes. I'm sorry. Did I say 737? I'm sorry.

CHAIRMAN FRANCIS: One of those 7s.

MR. PEREIRA: How about today, Don? Is it available for that type of aircraft today?

THE WITNESS: Yes. In June, we will have a certification for the 747 family, 200 and 300s. Boeing has a program to certify as quickly as possible production airplanes, and this week, I think, or maybe it was the end of last week, their 777s now are certified. So, anything leaving the factory will sooner or later have this kind of a system on it.

MR. PEREIRA: So, then Korean Air's fleet of classic 747s could be retrofitted after that point?

THE WITNESS: After June, yes.

MR. PEREIRA: What would a typical retrofit like that cost for a Korean Air 747?

THE WITNESS: Well, I'd say on the order of about $80,000 kind of thing. Most of the sensors are there, but they have to do -- it's the installation costs. Nothing goes into an airplane that's simple. It has to have some work on it.

MR. PEREIRA: So, that would include -- that would be an approximate number for both the hardware and the labor to install it?

THE WITNESS: That's correct, yes.

MR. PEREIRA: Does that include any rebates for trading in their old?

THE WITNESS: No. If the equipment is relatively new, and I think in this case, it was, there -- I'm quite sure financially, our sales people would make some kind of a trade-in because they're usable units to sell.

You asked me a question about the kind of equipment that was on the airplane, and -- and to -- to Korean Air Lines' credit, they had updated their original Mark-2, replaced it, updated it. It was a little late, but they did it, and they did it in August 1994.

With that, they got additional performance. They got wind shear detection alerting which is on most -- I think it's a requirement on all U.S. airplanes in the United States. They got radio altitude call-outs, and they got better immunity to unwanted warnings.

Do I have one more? Yes, that one right there. And as Captain Woodburn said this morning, if you don't know what you got for unwanted warnings, how can you improve anything?

This is -- with their permission, I show this. This is what it was like in 1993 for amount of unwanted warnings already across their fleet. They were having for that time span down there. This is for an A-320, but British Airways not only complained about unwanted warnings but produced hard data from what we call the focal program, and it was -- they have an excellent relationship with their pilots. So, it was not -- it was not -- it was meant just to try to improve the equipment.

So, progressively down to three years ago, we were quickly reducing the unwanted warnings, and we're still getting further improvement. So, the benefit that the Mark-7 that went into the Korean Air Line did get the -- the benefit of those unwanted alerts.

MR. PEREIRA: Okay.

THE WITNESS: The reduction in their --

MR. PEREIRA: And you did a simulation for us of the performance of the Mark-7 GPWS that was on Korean 801. Can you summarize that simulation in your findings and then advise us whether or not the simulation indicated that it performed as expected?

THE WITNESS: Okay. Go ahead. With -- with the aircraft in landing configuration and the Mark-7 that was installed on the airplane and a relatively stable descent into the terrain that was short of the runway and with no glide scope, there would have been no warning or alerts.

Radio altitude call-outs may have reinforced the pilot's situation perception of the distance to the DME if he was misunderstanding the DME was not -- was -- the DME was looking at was on the runway and unfortunately it was not, and apparently the Smart 500 with procedure was apparently not used, although almost all operators in the world now are using 500-foot call with a procedure that if you do not have the field in sight, as Captain Woodburn said, or see the runway approach lights in sight, you ought to wave off.

I don't know why the pilots flew through the last different altitude call-outs, but on the simulation tests we ran, --

MR. PEREIRA: Don, you mentioned -- just to stop you briefly.

THE WITNESS: Hm-hmm.

MR. PEREIRA: You mentioned that almost all carriers are using the non-precision approach, the 500 missed approach practice?

THE WITNESS: Yes.

MR. PEREIRA: Could you give us an example of some of the airlines that you're aware of?

THE WITNESS: Well, British Airways was one this morning. I think he didn't say that, but that's what he meant. United Airlines and -- and many of the U.S. other airlines, too, are doing that. Hm-hmm.

MR. PEREIRA: Have -- have you as a company disseminated your recommendation for that policy to airlines?

THE WITNESS: Well, we've put this -- all our equipment has this provision, and whether it's -- whether it's used or not depends on the operations people. I feel my company hasn't been strong enough in jumping up and down and maybe advising -- not advising, but asking them to do this, but we have recommended it.

When we put what we call the Mark-6 into the regional 135 operations, the 10 to 20 seats, that was mandated a few years ago, we rigged it so that it had to be disconnected. We built it in so the only way the airline could not have a Smart 500 was to disconnect it deliberately. But I think in this case, we met the provisions, and I think we were responsible in putting the provisions in, but maybe we didn't do a strong enough case in getting to the operations people on doing this.

But the Flight Safety Foundation and the airlines themselves have talked about this, and, so, I don't think it would be a surprise or something an airline, if they really wanted to work it, would know about.

MR. PEREIRA: Okay. Thank you. You can go ahead to the simulation.

THE WITNESS: From the data you gave us, we ran a flight path profile and -- and the radio altitude. The radio altitude had to be derived, which is unfortunate. Unfortunately, I didn't learn until yesterday, but we don't even have glide scope signals on -- on the FDR, which is very, very difficult for you investigators, but we ran that simulation, and we got one single sink rate, which correlated within half a second of the actual recorded time.

The descent rate was momentarily building to maybe something like 1,200 feet a minute, and we're down to less than 200 feet above the ground. So, it was -- it was a legitimate call.

The actual GPWS computer was recovered, as I understand. I know that it was recovered, and it was brought to our facility. It was -- it was significantly damaged. The front panel had been literally ripped off of it, and there was some damage to the IO, but some data was recovered from it which I think is significant.

The flight history for the last flight, which is Flight 1, as we call it, logged in one sink rate, which agreed with what was heard on the CVR. What we didn't understand, there was one mysterious bank angle logged in, but nothing heard on the CVR.

The bank angle was something you don't hear until you get to about 40 degrees of bank angle, but it also, when it gets down to about a 150 feet or less above the ground, it shortens up to about 10 degrees. So, I may -- my feeling and my -- my opinion is that the system was still functioning as the airplane was breaking up, and -- and -- and even though the CVR didn't log it in, there may have been some broken wires or something, but, anyway, it was -- the system was functioning.

I'd like to comment on this phenomena of -- of -- we talk -- we talked about -- I'm an engineer, and I'm a little worried about why radio altitude call-outs didn't break the train of thought. I'm not a human factors person, and as we said, this system worked as it was designed and installed, but why would a crew fly to the DME if that's a possibility?

I mentioned the suggestion is that if they were hearing call-outs, it would -- it would reinforce their thinking process that they really were going to the airport, and maybe that explains some of the initial call-outs but not for the latter ones.

Individually, I pulled out 88 international airports around the Pacific Rim, just to see how many times this occurred, and I also went back to a history, which I collect a lot of history, and I've got over 300 of these things, 300 of these things, and we can go on and on and on, and as the last speaker said, if we don't do something, we're not going to stop it.

It's a spectrum of things we've got to do to -- to beat it, to eliminate this as a loss of life and airplanes.

Out of the 88 airports I looked at, only six percent -- only six, that's about seven percent, had a single DME located off the airport. Yes, we know there's one off in Frankfurt and D.C. and so on, but those airports are typically filled with other nav aids, such as localizer DME or glide scope, and I've listed another two out of this list of 88 were without a glide scope approach aid.

if the glide scope had been operative at Guam, then we probably wouldn't have -- maybe this would not even -- it would not have been considered, but the key thing is here, is a single DME integral to the approach procedure and no glide scope.

Looking at the -- yes, the next one. Looking at the -- the probability of this occurring, it's a rarity. It's a rarity for these airports with an instrument approach procedure to have the only procedural DME located off the airport and with also no operating glide scope, and the crew in this case -- it would be interesting to go back and take a look, but I bet they flew the majority, 99 percent of their time, with no -- during just ILS approaches and no non-precision approaches.

So, the glide scope out at Guam, it became a non-precision approach with this additional hazards as one can identify, the airline can identify, and the CFIT control list. It's at night. It's a non-precision approach. It's over unlit terrain, on and on and on. These all give you assessments of -- of the risk involved.

So, the crew certainly is not perhaps groomed or -- or up to speed on non-precision approaches. That doesn't mean that they're not -- not -- that they don't have the skill factors or not, but they probably may not be expecting it.

An insidious CFIT trap then to my mind is the only DME navigational aid located off the airport and no glide scope data. Well, what does the history show? So, I went and looked at the history, and there were actually two examples of where the same thing almost happened to other airplanes and crews and passengers as what happened at Guam.

One -- the first example is in Lagos, Nigeria, a 747-200, and -- and the second one would be the St. John, British Columbia, in Canada, with a deHavilland-8.

Looking at St. John, the procedure for that, I know you can't read that back there, but maybe you could focus right on that DME in the airport. Can you do that? If you can look at that, and you'll see the airport is to the right of your screen at the bottom -- not the bottom, mid-part of the screen, and you see the VOR DME, which is like at Guam, off the field. It's about 5.3 miles off.

On this particular dark night, rainy and so on, this -8 -- next view foil, please. At Fort St. John was making this approach, a non-precision approach. You can see that the airplane almost hit the tower, the VOR and the tower on there. In fact, the crew believing that the passengers actually saw the tower go by above them, he -- he -- he reported it, as he should have, to his airline.

At the time, I didn't quite understand this because the airline said it was a mis-set VOR radio. I truly believe that they believed, the crew believed, the DME was on the field, and the reason this accident was avoided or potential accident and to keep it an incident was the fact that the airplane was not configured for a landing. It gave a Terrain, Terrain, Too Low, Terrain, and enough sufficient time anyway for the airplane to be -- the flight path changed and the recovery made.

The next -- my thanks to the operator. He's trying to improvise. I show on here two procedures, and the crew on this dark night -- sort of zero in on the right screen -- the right part of the screen or the -- yeah. That one. Just for the moment and sort of zoom in on it.

You see this is an ILS. It's a VOR ILS. It's got a DME that's off the field, and it also has a DME on the localizer, and many of the fields, I mentioned the Pacific Rim, have localizers, and they all have DME. I wish every localizer had a DME on it, but, anyway, this is what the crew expected, and when they arrived, that's the life of the pilot, is the unexpected. Regardless of what was NOTAMed or not NOTAMed or anything else, and that's why pilots have to talk to each other even before they start a trip, -- let's slide it over to the left. The other approach procedure.

This is what -- without any knowledge or clearance from the tower, he suddenly was faced with a VOR DME approach to Runway 1-9. He had no -- he didn't have the luxury of a DME on the localizer and the rest of it, and the localizer was -- the glide scope was flaky. I mean was -- it was moving around with a flag once in awhile, and that's what alerted the crew in the first place, maybe something's wrong, even though it's not NOTAMed or not referenced to them.

The next view foil, please. This is what the flight path profile would look like. They had prematurely descended to the DME, and the co-pilot calling out altitudes and distance to go, and -- and the crew is a vigorous -- I mean the airlines are vigorously enforces or practices CIM and -- and believes in the non-flying pilot speaking up when it's appropriate.

The co-pilot -- the navigator spoke up, the flight engineer, which they apparently ignored because they said, well, he's sitting back further, even though he's spoken up, he can't see -- really see the lights, which we can see, and they could see some lights, but as they got down further and further, they had a thousand-foot call-out, but when they got to the 500-foot call-out, it's what we call a smart call-out, it's normally not heard on the glide scope, with the glide scope working, and you're on the glide scope, the crew remembered that the procedure was to get out of there.

If you don't see the approach lights, you don't see -- you're not stabilized and configured for a landing, you wave off, and that's what Captain Woodburn was saying. It's very, very important that we do this.

I picked two of these just from a selection of a chart I made up which shows a whole bunch of these. These -- this trap of misusing the DME, being misread, misinterpreted or DME -- there's a DME hole in general aviation airplanes, is -- is -- is much more common than I ever thought it was, and let me -- when we worked on the Flight Safety Foundation, we tried to classify many of these into what we called traps, traps that inadvertently will trap the controller or a pilot, and that's my -- what I wanted to comment about anyway at the Guam situation.

MR. PEREIRA: Okay. In the case of an aircraft, an old aircraft, like a 727, for example, that doesn't have an FMS or a GPS, how do you go about completing the installation of Enhanced Ground Proximity?

THE WITNESS: Well, GPS is progressive, rapidly progressing to all the airplanes. It's still expensive, but in many units, we're putting a very low-cost engine, we call it engines, about the size of this credit card. Inside it is the whole GPS receiver, and we -- the cost is less than a thousand dollars to buy and put in there. We obviously want to make a profit on that, but the biggest thing to the airline or the most expensive thing in the airplane is to find room for an antenna on the roof, but it's a minor thing, and many airlines are going to do that, are doing that.

MR. PEREIRA: And if an aircraft doesn't have an EFIS display or weather radar display, is there another display type that can be installed?

THE WITNESS: Well, the minority of airplanes that don't have some kind of color display is -- there are a few. The old 727s and some of the DC-10s, maybe. But ourselves and others are offering very relatively little cost -- nothing's low cost in the aviation business, but very small displays that can be located in a central position or a key position for the pilots, and that's -- a lot of airlines are doing that, too, are thinking about that.

MR. PEREIRA: Similar to some of the small TCAS displays maybe?

THE WITNESS: Yes, it's about -- what do you call it? A 3 ATI. It's -- it's about -- it's about three inches diagonally, and there's a larger one that's a five-inch.

Amazingly, the general aviation corporate planes, they're putting these things, enhanced systems, into their airplanes faster than the airlines are with no mandate. It's wonderful.

MR. PEREIRA: With everything going so fast as far as demand, are there any problems with meeting the demand regarding production or certification?

THE WITNESS: No. As I said earlier, we've shipped -- I mean we've shipped over a thousand units earlier in the year. This year, we'll ship another -- easily another 2 -- 2 to 3,000 units to satisfy the on-going orders, and that's more -- you know, you add that up, that's more than half -- by the end of this year, we will have more than half the American airline fleet fitted, if we can get some help and cooperation from the FAA.

MR. PEREIRA: Do you mean onhte STC process?

THE WITNESS: Yes. Certification process is turning out to be the bottleneck, and we -- we need to do more as a country to encourage other countries to -- many of the countries do not have an experienced certification branch. They rely -- whether we like it or not, they look to the United States as a leader.

Sometimes we're a rather shabby leader, but we're a leader, and a leader in the aviation business, and we need to make the FAA -- try to help those people. We're not asking for extra work.

As someone said this morning, many of the FAA people are good people. Most of them are good people, and most are over-worked, but we got to find a way of doing it, if we're going to remain the leader in safety.

MR. PEREIRA: Can you describe some of the STC problems, and what you think the FAA can do to --

THE WITNESS: We still have only one person in the Seattle office that's handling these certifications. We need to streamline the process and make it grow. It's easy to throw bricks at the FAA. We are part of the problem, too. We need to be -- we need a memorandum of understanding, an agreement, with the FAA so we can use more informed engineers and so on to get this equipment in.

MR. PEREIRA: You mean like a DER kind of situation?

THE WITNESS: Yes, a designated engineering representative sort of thing, and it's working. It's -- but it's -- I'm -- you know, I'm a very impetuous -- I get -- I want to go and get it done right away, and I think in most cases, our customers, the airlines, want to do that, too. So, I'm hoping that the FAA can help.

The FAA's becoming more and more expensive to get something approved and certified, but I know they're trying, but they need almost -- bad nights or bad days, I go back to saying we need a revolutionary reform going on in the FAA, but I think they're trying to help.

MR. PEREIRA: Could you just briefly explain for some of the audience the reason why an STC is there? If you design this Enhanced GPWS, and it gets certified for one airplane type, why is there a delay in certification for another airplane type?

THE WITNESS: I think it's -- it's unfamiliarity, ignorance, on our part. We should be out training and making more people more aware what the system is, and there's a great conservatism. It's almost like tar or molasses in trying to get some changes made in regulatory bodies.

As the previous speaker spoke, I feel very strongly if we don't get our regulatory bodies involved in the safety process, really working with us at the -- at the start of these things, there's no commitment on their part. It's not going to happen.

Five years ago, the FAA didn't -- they believed there was no CFIT risk. The NTSB didn't. But the FAA didn't think there was any kind of risk. It took Cali, it took -- even the 129 accidents that were going in and out of the United States with FAA people on board, it still didn't get their attention, and, finally, when we had Dubrovnik with a 737 carrying the Secretary of Commerce and a bunch of business people, then it really got started to get the attention, but up to then, -- everybody wants to get out on the bandwagon now, but we need fundamental regulatory involvement right up front, and the Flight Safety Foundation is the place to start with.

As the previous speaker said, we couldn't get one air traffic controller or manager from the FAA to come, and here we had a separate committee on ATC. We couldn't get many of the world body to -- there was -- there was this great wall between air traffic control and flight standards or flight operations, and this shouldn't be.

I'm ashamed. I've tried to phone and get information from the FAA on the MSAW system because MSAW system, and what we're doing are very, very similar, and very, very similar, we have -- we must have similar problems, and we have similar problems, maybe we could collectively work on them, and we've done a lousy job on that.

I was very impressed with the previous witness two days ago that said they're ready to do something about MSAW. I know I've wandered off a little bit, but MSAW has saved a lot of airplanes in the United States, and shame on us for not doing flight inspections on a system that's put in there.

If we were to do that in our equipment, we would be hammered so hard on software, the lack of software and everything else that they did, we would financially pay a terrible price for that and also a moral price for it.

MSAW is something that's here, and I have -- we have no business leverage on this or -- the -- the rules -- air traffic control radar, almost all of it has got the hooks in for the United States MSAW system. Not one country -- okay. There may be an exception, but in my eyes, one country has really vigorously worked this.

The United States has tried to help, I believe, and I believe the FAA could make it even better if they could write the thing simpler about what the system is, but every country in the world should do this. Shame, shame, shame on any country who doesn't utilize the existing MSAW, the equipment's in place.

We're going to -- we're losing lives out there, and MSAW is a wonderful system. It's been bought, it's there, and the radar's been bought and paid for. It could be made to work very easily just with some determination.

I know there's a political problem. The -- you know, in some countries, the controller has no protection against -- if he makes an error, and it results in an airplane being piled in, he can be held -- charged with manslaughter. Pilots can be thrown in jail. We don't have the kind of environment that -- that kind of legal protection that should be worked out for those MSAW people -- I mean the controllers and for the pilots.

We have to work, unfortunately, in a very harsh environment, but MSAW is something that could be done and would save airplanes today.

CHAIRMAN FRANCIS: Let me just make a comment about the STC in a broader sort of look at this issue. I took the opportunity at the last break to -- to talk to the FAA about this. I think that they've gotten the message in terms of the -- the kinds of cooperative efforts that are necessary here, and I don't -- while the FAA certainly has its share, as you pointed out, there are all of us that have conservative people and don't know everything that we can be doing, but I -- I do think that -- that it's particularly incumbent on the regulatory authorities to be -- to be active in this area, and where you have -- where you have a situation with a major effort going on and the activity that is killing the most people in the world and to not have the regulatory authority and the air traffic control authority actively involved is -- is -- is unfortunate at the very weakest way that one could put it.

So, I think that the FAA is getting this message, and I certainly think that the -- the Administrator of the FAA is certainly in everything that she says and does very philosophically and actively involved in -- in these cooperative kinds of efforts that -- that this represents.

So, I'm confident, and I hope, and I certainly personally will -- will be involved in trying to make sure that -- that we all go forward with this, including the STC issue.

THE WITNESS: It's -- the industry really -- the airlines, they're really sincere about improving safety. Well, maybe some aren't, but most are, and you're right, the FAA, the manufacturers of the air frames, they all have a very positive outlook on this, and there's many people in the FAA have a very positive outlook on this, too, and all we need to do is cooperate and get -- and do it. That's all.

CHAIRMAN FRANCIS: Charlie, do you have more questions?

MR. PEREIRA: Yeah. I have a few more. Do you think -- you mentioned that MSAW is very important, and obviously GPWS is very important. Do you think there could be some better coordination on the technical level or a committee level between the people responsible for GPWS and MSAW?

Everyone seems to have taken a separate isolated approach in terms of systems to this point. Do you think perhaps the Flight Safety Steering Committee or some other steering committee could bring those two efforts together to try to see how the -- you mentioned we have a five-degree climb angle for the one warning envelope and 60-degree climb angle for the other envelope.

Do you think that there could be some coordination that could help improve each side?

THE WITNESS: Well, this meeting was very -- this hearing is very informal to me. I didn't realize the MSAW system was not working, actually deliberately almost disconnected, if not that.

I just didn't realize that, and I make a personal vow to myself that I'm going to talk to the FAA about the two systems, try and drag them out together. We -- we can do a lot of good together talking about this. They have the same kind of system as we have, and we just -- it's unfortunate, and I -- and I accept some responsibility for not talking, but I just didn't realize they were restructuring and reformulating the processes for MSAW.

MR. PEREIRA: And then I have one last question. I just wanted to verify. We didn't get to touch on it, but the simulation that you performed for the Korean Mark-7 GPWS, did that indicate that it functioned properly and as expected?

THE WITNESS: Yes. It logged in the fact that there had been a sink rate alert. You had a sink rate alert on -- on the -- on the CVR, and that all correlates for -- well. The system, I hate to say this, worked as designed.

The thing we really didn't know, as I pointed out, we need to know where the end of the runway was, and we're getting that information now, and that enables us to -- to provide something better. But at the time we had, the equipment did its job and functioned as it was designed.

MR. PEREIRA: Okay. Thank you, Mr. Bateman. I have no further questions.

CHAIRMAN FRANCIS: Can I just make another editorial comment here because it's interesting that Don's here. The importance of this hearing and -- and conferences and meetings and having people at -- at these kinds of events. I mean we've all got to make an effort to have our people out in the community talking with other people, and I'll cite a personal instance.

Don, I flew with him in the -- in the King Aire where they demonstrated this, and as we were flying back, I asked him if he knew John McCarthy, who at that point was at the National Center for Atmospheric Research, doing very similar kinds of work. They were working on displays for weather for pilots on glass displays in aircraft, and it turned out that these two people knew of one another but didn't know one another.

So, we ended up because of this generating a meeting between -- between Don and John McCarthy, and I believe they're now working together to have a coordinated effort to display of weather and terrain data on display. So, we've all got to be out talking to people and communicating and being aggressive.

We can't say I can't afford to send somebody to this meeting because he'll be out of the office for two and a half days, and it will cost $300. We can't afford as organizations, whether it's the FAA, the NTSB, or Allied or whoever it is, not to have our people out talking with other people, because this is showing us what we're losing and what we're wasting.

Korean Air?

CAPTAIN KIM: Thank you, Don, for giving us a chance to speak on a few matters.

Mr. Chairman, we've had some difficulties in the translation and live interpretation going on, and for the benefit of the people who will not have access to the recorded transcript, we would like to clarify just a few points. Do we have your permission?

CHAIRMAN FRANCIS: Briefly.

CAPTAIN KIM: Briefly. You used the word "retrofit". Would you please explain that in a few words, what retrofit process involves?

CHAIRMAN FRANCIS: Do you want me to explain it or Mr. Bateman to explain it?

CAPTAIN KIM: Don, would you please explain it for us?

THE WITNESS: Well, retrofit to me is -- is an older -- an airplane that's been delivered by the aircraft manufacturer and is in service, and, so, if you want to put something new on it, that's part of retrofit. You may be retrofitting older equipment that's on -- an older system on the airplane. That's what retrofit in my mind means, is replacing.

CAPTAIN KIM: And I remember, if I may quote, you said it was to Korean Air Lines' credit to -- to have updated the Mark-2 system to the Mark-7 which is the most current model available for the accident airplane, is that correct, sir?

THE WITNESS: That's correct.

CAPTAIN KIM: Thank you. And then just two points on the comments you made. You said about 99 percent of the precision -- the pilots would fly 99 percent precision approach and with no non-precision approach experience. Would you say that's a conjecture on your part?

THE WITNESS: Well, the number of nav aids and the preference by most pilots to fly a glide scope is very high. It may be not 99 percent. It's going to vary, depending on your route and the particular airport you go to. It's amazing how well equipped the international airports are equipped.

CAPTAIN KIM: Right Would you say that the 99 percent figure that you quoted differs from the facts established on the first day of and the second day of this hearing?

THE WITNESS: What facts was that?

CAPTAIN KIM: About the testimony of our witnesses regarding the exposure to non-precision approaches.

THE WITNESS: Well, I don't want to accuse them of -- of giving erroneous testimony or anything because I think they probably gave what they thought was correct testimony.

I did personally look at 88 airports around the Pacific Rim. So, my observations were based on those.

CAPTAIN KIM: Thank you. And the Smart 500, regarding that, you said almost all carriers use this procedure, is that correct, sir?

THE WITNESS: Yes.

CAPTAIN KIM: And then how many carriers are you aware of throughout the world?

THE WITNESS: I think it's sort of like assume it's been done. We mentioned British Airways, United. I've never paid much attention to this. You can say all the small 10 to 20 seat airplanes, they're all using it, too. It's become a -- it came out of the Flight Safety Foundation.

The first carrier I know that used it was -- was Pan American Airlines.

CAPTAIN KIM: Would you allow me the disagreement with your comment about almost all worldwide carriers have used the Smart 500 procedure? Would you allow me that --

THE WITNESS: Yeah. You can disagree, if you want.

CAPTAIN KIM: Okay. Thank you. No further comments. Thank you.

CHAIRMAN FRANCIS: Barton?

MR. EDWARD MONTGOMERY: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: Boeing?

MR. DARCEY: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: KCAB?

MR. LEE: Thank you. We have no questions.

CHAIRMAN FRANCIS: FAA?

MR. DONNER: No questions.

CHAIRMAN FRANCIS: NATCA?

MR. MOTE: Thank you, Mr. Chairman. No questions.

CHAIRMAN FRANCIS: Guam?

MR. DERVISH: Thank you. No questions.

CHAIRMAN FRANCIS: Mr. Feith?

MR. FEITH: No questions.

CHAIRMAN FRANCIS: Mr. Cariseo?

MR. CARISEO: No.

CHAIRMAN FRANCIS: Mr. Berman?

MR. BERMAN: Thank you, Mr. Chairman.

Mr. Bateman, would you please comment on the procedure for GPWS alerts that doesn't mandate a go-around if a sink rate or terrain secondary-type warning is received in instrument conditions? Have you -- are you aware of any air carriers that -- that do have such a mandatory go-around?

THE WITNESS: Well, I can speak my opinion, I guess. When we first started with GPWS, all we had was a whirling tone that something was wrong, and then when Boeing really got started to pursue trying to make this piece of effective safety system, we added in the 747 days the word "pull-up", and a lot of the procedures then were rather dogmatic.

Then we introduced voices, which Mark-2 designs or second-generation designs that are reflected where we had sink rates, glide scope alerts and so on, and -- and these -- depending on the situation, my opinion is anyway you may -- you may mis-correct the flight path if you have -- if you have assessed the situation in the cockpit, everything's all right, you maybe can see outside, it's probably a modest -- it's -- it's not a significant thing that would call for a go-around or missed approach.

But if you got a sink rate in the dark, and you don't see the ground, you better think twice. You better assess your situation, assess the instrumentation you have to work with, and -- and how far you are in the approach. You may want to get out of there right away, and some of the airlines, I think, are teaching that. I'm not an expert in flight operational matters, though I am a pilot, but I think some of the -- I think all the airlines would -- would like the crews to take deliberate best approach procedures on hearing an alert that they shouldn't have -- should not be hearing at that point in the approach.

Glide scope is heard quite often, but it's -- it's an advisory. There's usually sufficient time, but in most cases, they take corrective action to get back on the glide scope, and that's the end of it.

MR. BERMAN: Thank you, sir. I just wanted to get a clarification of one of the -- one of your statistics from a few minutes ago. I'd like to know of the two airports that you mentioned that had an off-site DME and no glide scope installed in the Pacific

Rim, on those two airports, is the off-site DME integral to the non-precision approach that is there at the airport?

In other words, is it used for identifying the final approach fix or a step-down fix?

THE WITNESS: Yes. I brought some notes along, but I don't have them with me, but there is a few of those, yes.

MR. BERMAN: Okay. A few of those approaches but only at those two airports, I guess?

THE WITNESS: Yes.

MR. BERMAN: Okay. Mr. Bateman, I'd like to put up an exhibit which is 9-D, Page 1. I'm sorry you don't have it in your package probably, but you'll see it on your screen momentarily. Okay. 9-D.

If you'll just pan down a little bit, Ted. Yeah. Right there to those two columns. That's the -- that's the results of the post-accident testing of the accident ground proximity warning system unit, and it has a counter of the warnings that had been received by that unit during the preceding, I guess, 5,442 hours of operation.

We note that there are a number of warnings that had been received in the history and -- and clearly understand some of those may have been due to testing conditions and other -- other issues, and I'd like to get your comments on -- on this history as you see it.

THE WITNESS: Well, you -- you put your finger on the first item. I mean the first thing I would respond with is quite often, the airline or the installation time or inspection may deliberately simulate conditions to get the alerts to occur. In this case, sink rates. They're very difficult to run, but where the radar altitude is closing very rapidly, so they had to test that.

So, you know, descent after take-off, those sink warnings, there's three of them shown here, that would be very -- very, very rare, if ever. I would think this is just a test condition that they did.

MR. BERMAN: Okay. I'm sorry. Go ahead.

THE WITNESS: Looking at this information here, it shows that there were 8 -- roughly 860 flights. I assume -- I don't know if this particular computer is the one that was installed at the time of -- of -- in August 1994, but it probably was. It may have been replaced. There's no indication of -- on -- it's a very crude warning counter.

MR. BERMAN: Are there different modes tested individually or -- or would you expect the mode counter to go up in any particular pattern for a GPWS test as you require them to be tested?

THE WITNESS: Oh, it depends on the test sequence they ran on the ground. Normally, when you do a self-test from the cockpit, it doesn't do anything to this flight history. So, this would -- when I look at this, this has actually been -- these alerts have either been caused in operation, real-flight operation, or in testing, and it's a very crude indication.

We were interested in -- in the flight hours and the hours operating time and the departures to help.

MR. BERMAN: Okay. Thank you very much. I have no further questions.

CHAIRMAN FRANCIS: Mr. Montgomery?

MR. MONTY MONTGOMERY: Thank you, Mr. Chairman.

Mr. Bateman, this looks to -- the -- the enhanced system looks to be a very -- very comforting item for a crew to have. It gives them an excellent sense of where they are relative to -- to dangers and does a lot of the worrying for them.

How does your system respond or -- or, better phrased, how would -- how would a crew know if they're flying into an airport where you do not have the digital terrain data available and the system performance is not as good as it could be?

THE WITNESS: That's a good question. In those areas I showed in blue, you were getting the airplane -- they would be showing what we call a purple haze. It's a light background to indicate the terrain is not there.

But as the airplanes have gone into service, and especially with Enhanced GPWS and especially those airplanes that are in corporate -- where they go to really strange places, they don't like to talk about them, we have discovered a few airports that were not -- that -- that -- that they're not in an airport database anywhere. So, we had to add them.

Typically they're like inside the area or some places. India was one place, but in schedule operations, it's been a rarity that we're missing airports.

One -- the Russians are opening up more and more civil fields for civil -- military fields for civil use. So, we've been surprised. Perm -- Perm in the Urals was one that Lufthansa ran into. So, we have to make quick update to add the runway ends, and when you -- every time you add a runway, you want to go into more detailed terrain around them, and, so, we've done that.

Does that answer your question?

MR. MONTY MONTGOMERY: Yes. Thank you very much. That's all I have, Mr. Chairman.

CHAIRMAN FRANCIS: Thank you very much, Mr. Bateman.

THE WITNESS: You're welcome.

(Whereupon, the witness was excused.)

CHAIRMAN FRANCIS: I don't think that it's practical to try to finish before lunch. So, we will now break for lunch. It's quarter of 1. We will be back here in an hour, please, quarter to 2.

(Whereupon, at 12:45 p.m., the hearing was recessed, to reconvene this same day, Thursday, March 26th, 1998, at 1:45 p.m.)

A F T E R N O O N   S E S S I O N

1:45 p.m.

CHAIRMAN FRANCIS: All right. Our next witness is Mr. William Henderson, Manager, Western Flight Procedures Development Branch, FAA Regional Office, in Los Angeles.

Whereupon,

WILLIAM HENDERSON

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

TESTIMONY OF WILLIAM HENDERSON

MANAGER, WESTERN FLIGHT PROCEDURES DEVELOPMENT BRANCH
FAA WESTERN PACIFIC REGIONAL OFFICE
LOS ANGELES, CALIFORNIA

MR. SCHLEEDE: Mr. Henderson, please give us your full name and business address for the record.

THE WITNESS: My name is William Henderson. I'm the Manager of the Western Flight Procedures Development Branch.

MR. SCHLEEDE: I'm sorry. I missed the -- I didn't quite hear.

THE WITNESS: I'm William Henderson, the Manager of the Western Flight Procedures Development Branch, and the office is in Oklahoma City, with the Mike Moroney Aeronautical Center, at 6400 South McArthur in Oklahoma City.

MR. SCHLEEDE: And what is your position with the FAA?

THE WITNESS: I'm the Manager with the Western Flight Procedures Development Branch. AVN-120 is --

MR. SCHLEEDE: Could you give us a brief summary of your education and experience that qualifies you for your current position?

THE WITNESS: Yes, sir. My formal education was in aviation business management with a semester of graduate work. I am an ATP pilot. I've got 12 years of experience with the procedures specialty in the FAA. I was a flight check pilot in procedures development, a specialty doing both things.

I was in the Southwest Region as an aviation safety inspector in the procedures and a retired Air Force pilot, jet instructor for 10+ years. I was the chief of the Standardization and Evaluation and the evaluation check pilot and the chief of the Instructor Pilot Upgrading.

I was also an Air Force accident investigator. I was a simulator instructor. After retirement, I became a corporate pilot. After that, I was a demo pilot for one of the largest GA distributors in the country, owned my aircraft, sales, and am currently an aircraft owner and an active pilot and have been since 1953.

MR. SCHLEEDE: Thank you. And when you mentioned procedures in the earlier part of your background, what -- in what -- what type of procedures? Could you elaborate?

THE WITNESS: Okay. Instrument approach procedures.

MR. SCHLEEDE: Thank you. Mr. -- Captain Misencik, proceed.

CAPTAIN MISENCIK: Good afternoon, Mr. Henderson. How big of a staff do you have in your office?

THE WITNESS: I have a staff of 35 that is in four different physical locations.

CAPTAIN MISENCIK: How many of those people are rated pilots?

THE WITNESS: I have, including myself, there's 13.

CAPTAIN MISENCIK: I see. Could you briefly describe your duties for us?

THE WITNESS: I manage the resources in those four groups, and in the instrument approach procedures specialty is what we work at, designing the procedure, setting it for flight check, and sending it for charting.

We also do the OE program, which is Obstacle Evaluations, of anything in our areas of responsibility that's to be constructed, and air space analysis, and environmental issues that become with the approach procedures that we don't need or the current environmental study, if we need one, or we can do an exclusion to it.

CAPTAIN MISENCIK: I see. What documents provide guidance for your duties?

THE WITNESS: Well, the two main manuals are the TERPS manual, which is 8263(b) and 8260.19(c), which is an FAA manual, and several other orders of the 86 series for some military or 15(c), 32(c), 34, 36(a) for MLS, 38(a) is for GPS, 37 is for helicopter GPS or MLS for helicopters, and 42, 44 for nav departures, 46 for instrument departures, and several others, but the -- the two main manuals are TERPS, that is for all joint services in the states that use instrument approaches.

CAPTAIN MISENCIK: Could you briefly explain for us the concept of TERPS?

THE WITNESS: TERPS, before I got into it, I believe it was about '68, it was adopted as a standards for all instrument approaches in the national air space system used by all of the users, the FAA, for the civilians, the Army, the U.S. Air Force, the U.S. Navy, and the Coast Guard.

CAPTAIN MISENCIK: And could you also describe the process by which an approach is -- approach procedure is developed and certified?

THE WITNESS: Yes, sir. The approach can originate from any requested source, airport owners, from pilots, air carriers or any other user. We funnel all of those through our flight procedures offices which are located at the regional headquarters to do the initial contact because we always like to -- we want the airport owner-operator to be involved, that he or she would want that approach to their airport. That requires a feasibility study to be done to see if we could possibly do one.

The additional coordination is -- the initial coordination is started there with all of the users at the different services, and the airport owner, air traffic AF airports, flight standards, the -- the user that requested that the owner of the airport, and if they have any pilot inputs at that time to see if we can do them.

They continue that process and gather eth data for the airport, so we have a firm good data to use, see if it is feasible. The environmental issues need to be looked at, as I said before, to see if we could have an approach and be friendly with keeping the noise down and environmentally.

As I am responsible for signing an exception to a complete environmental and we can do that if it normally follows the same traffic that flying in there without any increase in traffic as most instrument approaches do not increase it a lot.

After the complete package is -- initial coordination is accepted, and it's feasible, the environmental -- it's then sent to Oklahoma City where our specialists research the -- the procedure, seeing that we do have the good data, the best maps available, the largest -- the best maps, I mean the largest scale that we can use and have available, and design the procedure according to TERPS.

CAPTAIN MISENCIK: Excuse me. Mr. Henderson, could you maybe just get right down to the specifics of how you -- how you -- what -- how you construct a -- an approach procedure? What data?

Like, for example, the -- could you tell us how the 8260 forms fit into the process?

THE WITNESS: The 8260 form is the form that is filled out that has all of the pertinent data from the terminal areas to the missed approach and the final. It's put on that form, sent to flight check, flight check certification, and before it goes to flight check, it goes through our quality assurance staff to see that we're in compliance, and we go to flight check, flight checks, back for my signature, sent to NFDC, put on a transmittal letter, and sent to NOS for publication.

CAPTAIN MISENCIK: Okay. Could you tell us how the obstructions are located, and how their heights are determined for an approach procedure?

THE WITNESS: Map study and our instrument approach procedure's automated base that is updated weekly with all the obstructions that -- in a particular area.

CAPTAIN MISENCIK: How often are these obstruction heights checked?

THE WITNESS: The obstruction heights are verified on our flight inspection, and as you heard earlier, this flight inspection varies on different approaches and time when the reoccurring, and they're verified each time, flight checked, that the obstacle height is still there, and it's the same.

CAPTAIN MISENCIK: Is there any way to check on unauthorized or how -- how -- how is that taken into account, unauthorized construction or -- or tree growth?

THE WITNESS: Well, the OE program I spoke of awhile ago is a requirement that anything built on a 100:1 plain from an airport, there's a federal order requiring it be filed with the FAA, and anything over 200 feet any place is required. Have the specialists in areas that -- of responsibility in, say, the Western

Pacific Region that -- put our inputs into that program for every obstruction known.

If it's unauthorized, it's built, it's found on our flight check or if we have the pilot community will call in and say they see something being built, and we will investigate it, and it goes back to our OE program for that.

CAPTAIN MISENCIK: Okay. Thank you. When you develop an approach procedure, what determines the segment altitudes? Is obstruction clearance the only criteria?

THE WITNESS: No, sir. That is the minimum requirement, is obstructions. Then we have air space, environmental as I talked about, air traffic needs, users needs, and it just must fit the puzzle with everything else around it.

CAPTAIN MISENCIK: When -- for example, at Guam, we have an ILS procedure and a localizer procedure. Are the segment altitudes for the protected air space the same for both procedures?

THE WITNESS: No, sir. The altitudes are computed differently. The area is slightly different for the two approaches because the trapezoid or the area of protected air space from the final approach fits in is slightly different, in the missed approach is slightly different.

We use the worse case for both of them, could use the missed approach on -- for the ILS and localizer, but the localizer has a one required obstruction height all the way through it, and the ILS is the best we can do, and it gets down to which we know it was, 200 feet of a height above the airport for the DH.

CAPTAIN MISENCIK: I see. The -- would you say the ILS or the localizer has -- which one would give the -- the greater obstacle protection?

THE WITNESS: Well, the ILS because of the glide scope is a different protection. The localizer would have a standard of 250 feet versus the 200 feet. So, you would have more height above an obstacle with the localizer, but you don't have the glide scope. Glide angle is --

CAPTAIN MISENCIK: I see. Going back to the Guam ILS approach, are you familiar with the origin of the -- the ILS 6 left approach at Guam? Was that originally a military approach turned over?

THE WITNESS: Yes, sir. That approach to my -- best of my knowledge, and I can find out, has been there 20+ years. It was -- the ILS was commissioned in 1972, basically the same approach. The closing of different military bases throughout the world have opened up some of those airports for civil use. That airport also was a joint use civil use for all the time that I can -- back to those 20+ years that I've been able to find out.

But we took over the responsibility to design the procedure, and the closing was in '95. We got the procedure in '96, and it was an agreement that the Navy would keep the procedures in until the FAA could produce them because of the user's needs.

CAPTAIN MISENCIK: Are the TERPS applied differently at military airports, civilian airports, or joint use airports?

THE WITNESS: No, sir. The standard TERPS for all the services that use them, the military and the FAA, are all the same. The difference being a military has an operational advantage to do -- to change something in TERPS, they can do that with their operational advantage, but the approach would be noted as not for the civils to use.

CAPTAIN MISENCIK: Okay. Just to make sure I understand that, you're saying that the military could have a special approach, but that wouldn't be available to -- to the civilians on a regular basis? Is that what you're saying?

THE WITNESS: Yes, sir. That's -- and it would be noted that the civilians would not use that -- could not use that approach.

CAPTAIN MISENCIK: When a military airport becomes a civilian airport, like Guam did, was turned over, what time table do you have to have it flight tested, have the procedures flight tested to make sure they're in compliance with your -- your regulations?

THE WITNESS: We look at the procedure, and if -- we assume that it's -- it's all right until we find there was something different, and we would develop it. If we leave the procedure there, if it was needed, and there is no noted note for not civil use, that they could use it as they were doing it before.

When we developed the procedure, we will design it. If we find any flaws at that time, we would immediately correct them.

CAPTAIN MISENCIK: Has Guam been flight tested since it's been turned over?

THE WITNESS: Yes, sir.

CAPTAIN MISENCIK: Do you recall how many times or the last time that it's been flight tested?

THE WITNESS: I believe the last time at Guam was right after the accident, and that was a special was done, and that is not in my area of expertise of tracking flight inspection, except that it was done and commissioned.

CAPTAIN MISENCIK: Was it done since it was turned over but before the accident?

THE WITNESS: I believe it was. Yes, sir. I don't have those -- those dates.

CAPTAIN MISENCIK: That would be under -- where would we find that? On 8260 forms or --

THE WITNESS: You'd find some on the 8260 forms and would find it in the flight inspection operations that become the state's permanent records.

CAPTAIN MISENCIK: I imagine you've studied the -- the approaches at Guam. Do all the approaches -- are they in compliance with -- with the TERPS regulations?

THE WITNESS: Yes, sir, they are today, and they were when we published them. When we looked at those, there were two that were noted with high descent angles, higher than standard, that we changed the procedure to be the VOR. It was to 6 left, it was a straight-in with a higher-than-standard descent rate, and we changed that to a VOR alpha.

CAPTAIN MISENCIK: The -- the approach plate prior to the one that was in effect during the accident showed a -- a lower VOR crossing altitude than at the time of the accident. What necessitated raising that -- that altitude?

THE WITNESS: My recall that we had two changes on that approach. We have a requirement for the civil areas to have an air space requirement in the intermediate just prior to the final approach fix of a thousand feet above the ground, and then the obstruction that we discovered when we did the procedure raised the minimum at the VOR.

CAPTAIN MISENCIK: When you're developing or certifying an airport, do you normally solicit user group input into that process?

THE WITNESS: Yes, sir. We do that in the -- two times, basically. The original coordination from my office that's in the regions, and we send out requests at that time from the airport owner and -- and any of the pilot information that they may have.

Before the procedure is published, we send it for coordination with all of the user groups and give them 20 calendar days, and we use a standard 30 days before we would do any action on the procedure to give them a chance to review it and answer to us if they have any questions or recommended changes or --

CAPTAIN MISENCIK: What would be some examples of some of the user groups you solicit input from?

THE WITNESS: We use ALPA, ATA, AOPA, the American Airlines, ANR, whatever their user group of the American, the air traffic folks, the airport operators and the owners.

CAPTAIN MISENCIK: Do you have -- were there any significant comments or criticisms from other user groups when the Guam approach procedures were being turned over from the Navy and being certified by your office?

THE WITNESS: No, sir. We had none, and I checked with the Navy if they had any known users complaints or problems, and they had none.

CAPTAIN MISENCIK: When you're -- when the flight procedures office was transferred from the flight -- FAA Flight Standards to Air Traffic Services, how did that affect the way you did business, Mr. Henderson?

THE WITNESS: It -- it only changed that they were part of Flight Standards, and they did basically the same job that they were doing and fed the information to us to be used in procedures design or development and time frames. When they became our responsibility, they report to me, and then I have just a bigger area that I'm responsible trying to satisfy all the customers out there.

CAPTAIN MISENCIK: Did it affect the input from user groups in the process?

THE WITNESS: I don't think so. No, sir.

CAPTAIN MISENCIK: There's been some comments have come out regarding the Guam approach. They're in the factual -- operational factual report. One pilot said it's an unusual airport approach and takes a local knowledge to fly it. Another pilot said the approach to Runway 6 left has to be well briefed, and the pilots have to pay close attention to the approach to make it successful, and another pilot stated there should be a dedicated non-precision approach plate for the localizer-only approach to Runway 6 to help alert crews.

How would you respond to those user comments?

THE WITNESS: Well, first of all, I respect all those pilots' comments. I personally don't think it's a particularly difficult approach. I think local knowledge from any area in flying is beneficial. It has been my belief that the air carriers do that and have their captains fly it before they fly it as the captain to a place normally.

To the second part of that question was that the other pilots -- the second one was that -- oh, it was well briefed. I believe that is true. I think every mission -- every flight should be well briefed all the way from starting engines to shutdown.

And the third one of a different approach, I have been taught, and I taught as an instructor, when you're flying an ILS, you automatically would start timing at a FAF, which is not necessarily the same as the ILS, for the approach or if any reason, you lost the glide scope in your aircraft or on the ground, you could continue on the localizer approach as long as you hadn't gone below the MDA, and the approach is right in front of you, and you don't have to fumble and try to find another approach to complete it or make a missed approach.

CAPTAIN MISENCIK: Have you given any thought or consideration to making a dedicated localizer approach to the Guam ILS?

THE WITNESS: No, sir, I haven't.

CAPTAIN MISENCIK: Are you aware -- are you aware of any other approaches where a VOR is an integral part of the non-precision approach localizer procedure within the final approach segment and where the VOR is used as a step-down?

THE WITNESS: I can't recall particularly a

-- where there are VOR at that point. However, we have many, many approaches with a different piece of equipment or additional equipment required to fly the approach throughout the NAS. There's over -- there's over 10,000 approaches.

CAPTAIN MISENCIK: TERPS -- the TERPs procedure, 288(c), states in the final segment, "Minimum shall be published both with and without the last step-down fix, except for procedures requiring the DME."

Since the DME is not required in the final segment, why isn't there a 1,440-foot MDA also listed for this approach?

THE WITNESS: If you look at that paragraph, and that's the only thing you would consider, it has some shortcomings, such as a DME fix on -- the order 8260.19(c) states that as one area that you would have two sets of minimums.

All the -- the -- the requirements for second sets of minimums in 19(c) are additional pieces of equipment that the pilot does not need to fly that approach successfully throughout the complete approach.

On the Guam approach, the VOR is absolutely mandatory to have to successfully fly that approach entirely. If we had a second set of minimums for the

VOR without the VOR, in my opinion, that would lead the pilot down a path that he would think he did not need the VOR for that approach, and if he got down to the minimums and tried to make a missed approach, the missed approach is required for the VOR and the DME, and we -- if he had a lost column, there's no place to go, and he has no idea where he needs to go.

CAPTAIN MISENCIK: I'm not sure I understand why the VOR is required in its entirety for the -- for the approach if there would be VOR out minimums.

THE WITNESS: The VOR is a -- we use a -- a -- not a vector but a route to get in from the end route in case of lost column. We give the pilots a way to get to shoot the procedure. If you get to the minimums and make the missed approach, you must have a way to go to the missed approach, either holding fixed or the end-route system.

On this system that we have here, the uniqueness of having just one big VOR in this part of the area, that that is part of the missed approach, and the DME is the missed approach holding fix.

CAPTAIN MISENCIK: Could you explain the meaning of the note DME required on the approach plate? Do we need -- would you like to refer to it on the board? Could we have Exhibit 2-N, please, Ted? On the top of it, there's a note.

(Pause)

THE WITNESS: The missed approach is down here, but if I had -- we had minimums with this -- stopping here, the pilot would continue with this track without the VOR, he would be sort of lost in space and not having a way to get back to the holding fix and especially if you have a lost column, and that's where we take the worst case.

CAPTAIN MISENCIK: I -- can you think of another airport under FAA jurisdiction with an approach that has the note just DME required?

THE WITNESS: Having a note of DME required only? No, sir. But I can think of many approaches that have different equipment required from single -- this one VOR to VOR -- I mean DME to DME or radar or ADF required.

CAPTAIN MISENCIK: Couldyou explain why, if DME is required, it's not listed in the title, like ILS/DME?

THE WITNESS: Well, to fly a procedure or to be named on a procedure, the procedure name is arrived from what it takes to fly the final approach. On an ILS approach, glide scope intercept is the FAF, and the DH is the missed approach area. So, you don't need DME to fly that final.

CAPTAIN MISENCIK: Would a procedure turn on this as an entry to this procedure would have done away with the necessity for the note DME required?

THE WITNESS: No, sir. There's high terrain out in -- out in this area that a procedure turn would require us to maintain the thousand foot of clearance in here. We would have to develop DME fixes because if we came to here, we would have too steep a descent angle to make an approach from.

CAPTAIN MISENCIK: Well, I think the VOR Alpha approach has a procedure turn entry, if I'm not mistaken. Does it have a different procedure turn altitude?

THE WITNESS: No, sir. But that makes it a non-straight-in approach, and it's a circling approach only because of the height at the VOR. It's too steep to get down.

CAPTAIN MISENCIK: But it's still flying over the same terrain essentially, isn't it?

THE WITNESS: Yes, sir. But it's -- it is much higher than with the DME that we could put the final approach fix out farther.

CAPTAIN MISENCIK: The -- the note DME from UNZ VOR, what provides the specific guidance for that note?

THE WITNESS: There's a paragraph in our manual that before using a -- a DME, other than the paragraph, that we need to do that.

CAPTAIN MISENCIK: Is that -- the -- is that the paragraph that says that the note required is DME from -- and the way it's written in the book, DME from XYZ vortec, simultaneous reception of the ILS and the VOR, DME is required?

THE WITNESS: I think that paragraph you're quoting is an ILS slant DMEs or localizer slant or VOR slant DMEs.

CAPTAIN MISENCIK: So, that doesn't have any bearing on this one?

THE WITNESS: That's correct.

CAPTAIN MISENCIK: The 8260.19(c), Paragraph 814, states, "Avoid caution notes about obstacles. Notes such as high terrain all quadrants, steeply-rising terrain, etc., are not appropriate."

What is the rationale for that paragraph not to mention terrain?

THE WITNESS: It is my belief that that would put the procedure developer in a position to try to identify the terrain that they should chart, that if you ignored some piece of the other terrain would be accused of showing or requesting a terrain, and someone else would consider that another piece of terrain is the more significant one if they hit it, and if we fly the procedures as developed, the terrain is not a factor.

CAPTAIN MISENCIK: Well, what -- what's your opinion on including notes regarding significant terrain or terrain profile, at least on the profile view of the approach plate?

THE WITNESS: I believe still in the -- in an obstacle which area -- in other words, having several obstacles, which one do you define, and the problem becomes of what you don't define. So, I again don't think it's a good idea personally. The required obstacle clearance should keep us away from everything.

CAPTAIN MISENCIK: But the particular air space on the -- say on the approach segments has -- have finite widths, and if the highest obstacles within those approach segments would be defined, wouldn't that make sense?

THE WITNESS: Well, you could have the controlling, which would be the highest obstacle, but you could have several of those in there, and the chart clutter, if you put everything that was in that area protected air space, you'd make it almost impossible to see the rest of the approach.

CAPTAIN MISENCIK: Did any of the Guam approaches require a waiver of standards?

THE WITNESS: No, sir.

CAPTAIN MISENCIK: Are you familiar with PANS OPS or the ICAO standards?

THE WITNESS: No, sir. We are -- the U.S. standard is TERPS.

CAPTAIN MISENCIK: With your experience, both as an aviator and working in this field for some time, what is your appraisal of the TERPS manual and the guidance you receive for developing these approaches and certifying them?

THE WITNESS: The TERPS manual is -- has a lot of information. It takes a TERPS individual to be a journeyman specialist quite some time to master it and know where to look, but it's there, and with our 8260.19(c) and other orders for different types of equipment, I think there's several guidance. Some of it could be probably cleared as you talked about. The 288(c) that has two identifications, and our manual has many more areas of when you would need dual approaches and examples.

CAPTAIN MISENCIK: Well, are these manuals subject to interpretation? For example, in the case of

Guam, the localizer approach, there is no dual minimums published, but is that uniformally applied or under the same circumstances?

THE WITNESS: I believe it is. Any place that it's a mandatory required piece of equipment, it would not be appropriate to put a second set of minimums because it would lead the pilot to believe that if that piece of equipment was failed in his airplane or absent in his airplane, that he could fly that approach, and that he or she would be in serious trouble if lost communications and tried to make a missed approach.

CAPTAIN MISENCIK: Do you -- do you feel any changes to these manuals to clarify -- to clarify the points? Basically what I'm asking is, do you think these manuals maybe should keep up with -- with the times or are they -- what's your evaluation of them?

THE WITNESS: Well, I think they should keep up with the times, but when we design a procedure, we must consider what equipment can fly that procedure, and there are many airplanes of much less performance than some of the newer aircraft and equipment, and they must be able to fly the procedure as well as high-performance aircraft with the very best avionics.

CAPTAIN MISENCIK: Do you believe that the user input you're receiving now is adequate or should it be expanded on to take advantage of the technology advances in aviation, people who are familiar with the glass cockpits, the GPS?

THE WITNESS: We welcome all users' comments, and we will continue to do so, and the more user comments that we get would certainly not hurt anything and probably enhance everything we do, may even make it an easier for our designers when we're doing a procedure.

CAPTAIN MISENCIK: Have you recommended any -- do you recommend charting procedures or have you recommended any charting procedures which would make the charts more user-friendly to some technique, such as constant descent, that Captain Woodburn talked about earlier?

THE WITNESS: Well, I'm not quite sure what we -- if -- we -- we have parameters of glide descent. I think the procedure that we did at Guam, and the altitudes that would be computed, they're very close to a constant descent, if they were flown that way from point to point, but that's not the primary design, is the required obstruction clearances.

CAPTAIN MISENCIK: How do you feel about the inclusion of minimum sector altitude areas on the planned view as was depicted in the charts that Captain Woodburn showed to give the pilot a view of terrain he was flying over?

THE WITNESS: Those were very interesting charts that he had. As it appears to me that it would have some great advantage for pilots. However, that's the charting folks in Washington to do, and if chart clutter has always been a problem from all aviators and all airports we have, that that seems to be a problem, also.

CAPTAIN MISENCIK: Okay. As one of my final questions, when you develop a procedure and have it certified, and then the procedure goes to the chart manufacturers, like Jeppesen or Air Rad, or any of the NOS, how much leeway do they have in implementing the -- what they think should be on the -- on the chart?

THE WITNESS: They must put the information that we have on the 8260 forms that are sent, must be there. Our standard for the U.S. Government is NOS, and those charts are -- are charted. Those are the charts that my specialists check as soon as they are published, after -- before the public sees them or before they're in use for the public.

They may have a shipment before, but we make sure that everything is on that plate is what we have put on the forms, the 8260 forms. What other cartographers and other agencies of charting, I can't comment on that. It's not my area.

CAPTAIN MISENCIK: Based on the information we've received to date regarding the accident at Guam, have you any -- any thoughts on what you would like to see done or any recommendations you may make in developing approaches or in the future?

THE WITNESS: Are you talking about at Guam?

CAPTAIN MISENCIK: Anywhere.

THE WITNESS: The continued coordination, and I would use Guam as we're talking. We are working on two additional procedures for Guam that are R-NAV/V-NAV approaches, and they're in the coordination phase, and the original -- the first look.

At the same time, we will review all of the procedures that we have now, and on this particular area, radar was -- the air traffic told me that they at the time could not support full-time radar exceptions of doing the approach or required radar on the approach. They've got quite an area, I understand, and we will -- I will ask -- ask that to be revisited and see what they would think about having radar required or DME, and if the flight check fixes could be confirmed, they must be done before the radar fixes, and if that would fit into their scheme and the flow of traffic for them.

CAPTAIN MISENCIK: Thank you, Mr. Henderson. I don't have any further questions. I believe Mr. Feith may.

MR. FEITH: Good afternoon.

THE WITNESS: Good afternoon.

MR. FEITH: Pardon my ignorance because I stepped out of the room. So, I'm not really sure I caught all of the answers to all the questions that have been asked. So, if I am redundant, Mr. Chairman, I apologize.

CHAIRMAN FRANCIS: You are taking your turn now rather than after the parties?

MR. FEITH: Yes, because we are -- I may have a follow-up after the parties, too. But we'll get to that if I need to.

Let me just make sure I understand. There was some testimony on Monday regarding markers as they relate to an approach, and --

THE WITNESS: Could I get a little more volume on that? I'm having a little difficulty hearing you.

MR. FEITH: As -- as it relates to an approach, the outer marker and middle marker are not required parts of the approach? Do I understand that correctly?

THE WITNESS: Are not required?

MR. FEITH: Yes.

THE WITNESS: That's correct.

MR. FEITH: Okay. Teddy, could you put that chart back up? The approach plate.

On this, the question was asked regarding why isn't this an ILS DME given the fact that the note up there says DME required.

THE WITNESS: The -- the manual instructs us what it takes to fly the final approach, is what the chart's name. This chart takes glide scope intercept at -- on the glide scope and a DH. That's what you need to fly the approach, the final approach, and that's all it talks about, the final. That's the naming.

MR. FEITH: How do you identify the missed approach point?

THE WITNESS: DH on ILS.

MR. FEITH: Okay. If you look at this chart and just correct me if I'm wrong, the middle marker here is the missed approach point, if I'm -- if we're looking at the appropriate chart. Go up to the planned view, Teddy. I mean the profile.

THE WITNESS: We need some more -- the bottom of the -- it's the bottom of the approach. Over here is the decision height. That is the missed approach point.

MR. FEITH: Okay.

THE WITNESS: It is very co-located close to this, but that is the missed approach point on glide scope at that height.

MR. FEITH: Are you using DME to get to that point?

THE WITNESS: No, sir.

MR. FEITH: Okay.

THE WITNESS: DH.

MR. FEITH: Okay. Now go back to the -- the planned view, Teddy. With regard to trying to identify on a missed approach where the intersection is for flake, it says that it's seven DME out, you see the Note Number 1?

THE WITNESS: Yes.

MR. FEITH: If you didn't have DME or DME isn't required, how would you identify that?

THE WITNESS: You could not.

MR. FEITH: So, wouldn't you need to have DME?

THE WITNESS: That's why the note DME required.

MR. FEITH: Okay. But given all of that, should -- should there not be some sort of change -- I see the note up there, but is that an appropriate place to get someone's attention or to make sure that a pilot knows that DME must be used either as part of the initial part of the approach or a missed approach segment?

THE WITNESS: The question is do I think that having the DME required versus having it named DME --

MR. FEITH: Yes.

THE WITNESS: -- would be less or more for an experienced pilot?

MR. FEITH: Any kind of pilot because these charts apply to everybody, not just --

THE WITNESS: Yeah.

MR. FEITH: -- the commercial airline pilot.

THE WITNESS: I think it's the same.

MR. FEITH: Okay.

THE WITNESS: DME required. If it was an ILS DME, it would be required. The note on this one says it's DME required, and it is required for the -- the missed approach area in holding to get the pilot out of the low place.

MR. FEITH: Did you -- was -- I don't know if the question was asked. Since the accident, have they co-located the DME in the localizer?

THE WITNESS: No, sir.

MR. FEITH: So, it's still separated?

THE WITNESS: Yes.

MR. FEITH: Okay. Is there any plans to do that?

THE WITNESS: I -- I don't know of any. First of all, this -- the VOR here is the DME, and it's a major, major, very powerful VOR here in the Pacific area. It reaches far out. Historically, when we've -- the agency installs a procedure like that, it's up on a hill, and, so, it's not blocking out because if we have a VOR, mountains or other buildings or something can stop the radiation, and it's not near as usable.

MR. FEITH: And just one other question. You had talked about that you solicited comments from users on the approach or users of the approach during the course of -- of trying to determine what problems may exist on specific approaches?

THE WITNESS: If they have users -- air traffic is our probably first line of defense on users comments from someone who has been flying an approach because they will get the complaint, and they are very good at funneling those to us to tell us there's something wrong with approach, and a user has a complaint on them, and we will consider them all.

MR. FEITH: Okay. I don't have any further questions right now, but I may have some on the way back.

CHAIRMAN FRANCIS: Can I ask a question just on sort of a follow-up here? Is -- is it possible -- I understand your explanation of the -- you've sort of got a long-range VOR DME there for -- for a lot of en route navigation over the Pacific.

Is it -- is it technically possible to have -- to leave that facility as it is and put a co-located DME on the ILS?

THE WITNESS: Yes, sir. Having two DMEs, you're talking?

CHAIRMAN FRANCIS: Yes.

THE WITNESS: Yes.

CHAIRMAN FRANCIS: And -- and I am I guess you always have a problem of potential confusion, but if you -- if you -- if you dial in the ILS, you automatically get the ILS DME?

THE WITNESS: Some -- I understand, and from my experience, that there are some equipment that that's not true. We have -- the agency has had problems when we have two DMEs forward on the -- from an aircraft commencing its approach. They've had problems in the past, and we try to limit that and put very clear notes that -- and that is a potential problem.

CHAIRMAN FRANCIS: That was the question. So, -- so, the agency tends to try to avoid that because of possible confusion?

THE WITNESS: I don't know if -- that's not again in my area of expertise, but I know that is a problem, and what they tend to avoid, I'm not sure. That's a flight standards, and our AO folks are doing it.

CHAIRMAN FRANCIS: Thank you. I'm through. Finished.

FAA?

MR. DONNER: Yes, thank you, sir. Just one. In addition to using the DME for the missed approach, isn't it true that it's -- the DME's also necessary to locate the three initial approach fixes?

THE WITNESS: The initial approach fixes? Yes, sir.

MR. DONNER: Is there any alternative way to locate those fixes?

THE WITNESS: Not on this procedure because of an isolated island with one major VOR.

MR. DONNER: Thank you.

CHAIRMAN FRANCIS: NATCA?

MR. MOTE: Thank you, Mr. Chairman. We have no questions.

CHAIRMAN FRANCIS: Guam?

MR. DERVISH: Thank you. No questions.

CHAIRMAN FRANCIS: KCAB?

MR. LEE: Thank you, Chairman. Just one question. On the airport, when you look at the approach plates, on Runway 6 left localizer approach procedure, has the final decision altitude immediately after the accident from 560 feet to 580 feet -- it has changed to 580 feet, and then it was changed back to 560 feet again. They changed it to 580 feet, and then again it was -- it went back to 560 feet.

Was there any particular reason for that?

THE WITNESS: Yes, sir, there was. We were asked to evaluate the missed approach area in a 40:1 because of the approach plate chart had an obstacle that appeared it might be in the 40:1, and we evaluated it, and it was. So, we had a 20-foot increase on the

DMA.

However, that was -- that obstacle was not there when we originally developed the procedure. We have since researched that thoroughly and had it verified that that obstacle was in error, and it was a hundred feet too high, and we have since lowered the MDA back to its original because the obstacle was a hundred feet lower than we first believed when we looked at it.

MR. LEE: The question -- let me just ask you one more question. Based on the FAA tough standards, when there is DME available, you don't necessarily have to have the outer marker.

In the future, are you planning to continuously operate the outer marker? The reason I am asking this question is when we visit Guam, we visited -- when we visited Guam, we experienced malfunction on numerous occasions. It doesn't even have a monitoring function.

When you need a DME, I think it's probably more advisable to remove the outer marker and maybe better for the flight operation. Do you have any personal view on that?

THE WITNESS: I have no knowledge of the problem of the outer marker or any knowledge of planned removal. So, I can't comment on that.

The DME is also co-located when possible at the outer marker. The DME fix, I'm talking about. But I have no knowledge of removal or I have no knowledge of the problem that has been as you say for your flight crews.

MR. LEE: Thank you very much. That's all.

CHAIRMAN FRANCIS: Barton?

MR. EDWARD MONTGOMERY: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: Boeing Company?

MR. DARCEY: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: Korean Air?

CAPTAIN KIM: No questions, Chairman.

CHAIRMAN FRANCIS: Mr. Feith, you want another shot?

MR. FEITH: No.

CHAIRMAN FRANCIS: Mr. Cariseo?

MR. CARISEO: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: Mr. Berman?

MR. BERMAN: Thank you, Mr. Chairman.

Mr. Henderson, could you tell me when the flight procedures offices were changed to work under the Air Traffic Service?

THE WITNESS: The flight procedures -- they were called branches, was in April of 1995. The reorganization took place, and they become part of AVN at that time.

MR. BERMAN: Okay. Thank you. Since that time, has there been an increase in the number of procedures specialists who are not pilot qualified?

THE WITNESS: There are increases at Oklahoma City of non-pilot qualified, but if I could add, the hiring has been predominantly ex-military procedure specialists who retired, and most of them had from 10 to 20 years experience developing it for the military.

MR. BERMAN: These are the non-pilot specialists? That's what you're saying?

THE WITNESS: Sir?

MR. BERMAN: The ones who are non-pilots --

THE WITNESS: That's right.

MR. BERMAN: -- are in that category? Okay. Has there been any change in your office in terms of non-pilot specialists?

THE WITNESS: Any changes ni my --

MR. BERMAN: Yes, in your -- in your office in Los Angeles, have you hired on specialists --

THE WITNESS: No. Los Angeles are all -- have all -- have four pilots, and they're all -- that's my authorized strength there.

MR. BERMAN: Okay. Thank you. How does the FAA evaluate the flyability or the difficulty of an instrument approach procedure?

THE WITNESS: Well, that's a little out of my expertise now, but I was at one time a flight inspector, and it was -- we actually flew the procedure, and we evaluated it again for the lowest, in our estimation, quality -- not quality, experienced pilot, could he fly that procedure on the original commissioning flight check.

MR. BERMAN: Hm-hmm. And has that type of a procedure changed since the reorganization?

THE WITNESS: No, sir.

MR. BERMAN: Hm-hmm. Do you know how the ILS approach to Runway 6 left glide scope inoperative procedure was evaluated for flyability?

THE WITNESS: How it was evaluated for -- the -- we were doing the Navy flight check follow-on. So, the FAA was evaluating it from the original day of 1972 when it was commissioned.

MR. BERMAN: Okay. Thank you. No further questions.

CHAIRMAN FRANCIS: Mr. Schleede?

MR. SCHLEEDE: Just one clarification. Regarding -- again, I know you were asked, and I'm not sure I got the answer correctly. The approach at Guam that you were discussing, if it -- the name of it was changed to ILS/DME approach, would that change anything about the approach, where the nav aids would be or anything?

THE WITNESS: We would remove the DME-required note.

MR. SCHLEEDE: It could still be -- the DME could be remotely located. It does not have to be co-located at the localizer to be called an ILS DME approach?

THE WITNESS: It should be co-located and is required again to fly final on that approach.

MR. SCHLEEDE: You say it should be, but can be a non-co-located DME and still be called an ILS DME approach?

THE WITNESS: Yes, sir, if that was required to fly the final approach according to our book, or there'd be a waiver to that requirement.

MR. SCHLEEDE: Okay. Thank you.

CHAIRMAN FRANCIS: Mr. Montgomery?

MR. MONTY MONTGOMERY: No questions. Thank you.

CHAIRMAN FRANCIS: Thank you, sir. Appreciate your contribution.

THE WITNESS: Thank you, sir.

(Whereupon, the witness was excused.)

CHAIRMAN FRANCIS: Our next witness is Mr. James Terpstra, Senior Corporate Vice President, Flight Information Technology and External Affairs for Jeppesen Sanderson.

Whereupon,

JAMES TERPSTRA

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

TESTIMONY OF JAMES TERPSTRA
SENIOR CORPORATE VICE PRESIDENT
FLIGHT INFORMATION TECHNOLOGY AND EXTERNAL AFFAIRS
JEPPESEN SANDERSON, INC.
ENGLEWOOD, COLORADO

MR. SCHLEEDE: While you're booting up, let me ask you for your full name and business address for the record.

THE WITNESS: My name is James Terpstra, also known as Jim. My business address is Jeppesen, 55 Inverness Drive East, Englewood, Colorado.

MR. SCHLEEDE: And what is your position at Jeppesen?

THE WITNESS: I'm the Senior Corporate Vice President of Flight Information Technology and External Affairs.

MR. SCHLEEDE: And would you give us a summary of your experience and education that brings you to your current position?

THE WITNESS: I have a Bachelor of Science degree. Follow that, I was an instrument flight instructor and airline transport pilot before I joined Jeppesen in 1968. I first went to work for Jeppesen and wrote the -- a number of the textbooks for pilots to pass their FAA written examinations for the private, commercial, instrument, ATP, and then went to work in the charting department in 1973, where I was responsible for flight information design, eventually became responsible for all the production of all the charts and the databases.

MR. SCHLEEDE: Thank you. Captain Misencik will proceed. Oh, I'm sorry. Mr. Feith.

MR. FEITH: Good afternoon, Mr. Terpstra.

THE WITNESS: Good afternoon.

MR. FEITH: Mr. Chairman, I -- I had asked Mr. Terpstra to prepare a presentation regarding charting. Since Mr. Henderson was able to enlighten us on the information that is required by the FAA to determine an approach procedure, it is not up to the FAA to actually produce the charts, and, so, I'd like to have Mr. Terpstra just give us a brief overview of how they take the information that the FAA has on their specific forms and provide it to a producer like Jep to produce the approach plate procedures that are in use right now, both commercially and -- and GA-wide around the world.

CHAIRMAN FRANCIS: I saw that raft going down the river, and I thought maybe we were getting a marine-charting presentation.

THE WITNESS: That's a lot more fun than this, I can assure you.

CHAIRMAN FRANCIS: Go ahead, Jim.

THE WITNESS: Mr. Chairman, ladies and gentlemen, thank you for giving me the opportunity. I will do my presentation in a little different style than what we've been doing previously.

I prepared a presentationta the request of Mr. Feith, and my presentation is on instrument approach charts, and the three items which you can see up on the screen are our sources of information, how Jeppesen designs a chart, and the validation of the sources that we have from the various different government organizations.

MR. FEITH: Excuse me, Jim. Can we just drop the lights a little bit so that we can get better contrast? Will you be able to still see your presentation?

THE WITNESS: I'm doing fine. Thanks.

MR. FEITH: Okay.

THE WITNESS: Some of the material which I have prepared is a little bit of a duplication of Mr. Henderson's. So, I will go rapidly past the things which he has talked about, but you'll see some of the things that Mr. Henderson talked about now in a graphic form. So, hopefully maybe that will give you a better picture of some of the things that are in the input into what goes on in the world of aeronautical charting.

This is a picture of the approach into Runway 6 left at Guam. This is to show that the requirement for an instrument approach procedure is first established by airport and by user. So, this is the start of the entire process.

The process, the very first thing that's very important about this is what Bill talked about, and that is that the instrument approach procedures are designed according to a document which we call the United States Standard for Terminal Instrument Approach

Procedures, an acronym of TERPS, which has been used for that.

It's also important to know that thiss ia common document for both the U.S. military and the civilians who use the same standard, and this document was originally issued November 18th, 1967, but actually follows another document that was there for some time before. So, the business of specifications of standards for approach procedure design is not new.

In February, just last month, the Change 7 to the TERPS was signed. I said here it's issued. It really was signed, and it will be issued after it comes out of the government publications, but it's important that there is a continual updating of the criteria that goes into the TERPS, and we are now about to have Change 17.

We heard mentioned a couple times earlier today a document called PANS OPS. That's actually the international design, according to ICAO or the International Civil Aviation Organization. PANS OPS Document 8168, which is an equivalent document for an international standard.

MR. FEITH: Can I just interrupt you and -- and just for the benefit of the audience, can you just tell us what PANS OPS is?

THE WITNESS: PANS OPS is the document. It's not at an annex level. It's a level below, and PANS OPS is -- well, I'm not sure what that stands for. It's operations, but PANS something. Wally? Pardon? Yeah. Navigation Operations.

But this is the document that's, as I said, not as a standard, but it's a recommendation within ICAO which is used by most of the governments throughout the world as their standard for the design of the instrument approach procedures, and it's equivalent to the U.S. TERPS criteria. However, there are some slight differences between the two.

MR. FEITH: Thank you.

THE WITNESS: The illustration you're looking at here is the cover of the actual document that's out in the field right now. The next part of this I hope you can see, but what's important that you look at here is that at the bottom of the cover is a series of people who comply with this document, which includes the Army, Navy, Air Force, Coast Guard, and the FAA.

The reason that this is important is because this procedure originated as Mr. Henderson told you a number of years ago as a military instrument approach procedure and was eventually converted to a civilian approach procedure, but the difficulty in doing that is not that large because they both comply with the same criteria.

Some of the elements of the TERPS for the construction of this are from the en route environment all the way down through and including landing, and in the event landing is not accomplished, then also the missed approach procedure, and there are terms which are used, like initial approach segment, final approach segment, missed approach point and so forth, and each of these have a required obstruction clearance which is the amount of altitude between the flight altitude and the obstructions below that within a specified width. That also is what determines the landing minimums for each one of the approaches.

As Bill said, the tools that are available for the TERPS experts are very plentiful. They are all trained by the FAA in Oklahoma City. They do use the local topographical charts which are a lot of times the largest scale, usually about 1:24,000. They also use obstacles from the NOS Obstacle File. That is the National Ocean Survey branch of the Department of Commerce within the United States, who has the responsibility of collecting and distributing all of the obstacles throughout the United States.

In addition to what NOS has, if there are any obstacles that are known locally by the instrument approach procedure specialists, those are also included.

The next-to-last item on here, which is important, is the FAA has an instrument approach procedure automation software, and what this means is that there is now a much more standardized approach to the creation of instrument approach procedure because the variations in that are limited because the automation makes sure that the standard applications are done.

Also, it's very important that no instrument approach procedure can be accomplished until it has been coordinated with air traffic control.

The illustration you're looking at here is an excerpt out of the topographical chart that's on the approach in to Runway 6 left, and I think you can see the detail there, even down to some of the buildings that are surrounding the airport, and this is the information that's used to accumulate the terrain and the obstacles on the approach procedure into the airport.

Once those are done, they're flight checked by the FAA. They are then entered into the FAA Form

8260-3, which is for instrument -- for the precision instrument approach procedures or what's known as a -5 for the non-precision instrument approach procedure. There's also a -7, which is used for the tailored approaches as published by the FAA.

Now the part in here that you see is part of where we start to get involved. These are submitted to Oklahoma City for review, and then they are coordinated back with the designer of the procedure for any corrections that need to be made, and then they are sent to the aviation industry for review, and I think Bill gave you the list very well of people that do look at this.

At that point, we talked about a transmittal letter, but it's also submitted to the Federal Register, which is an important part, because it becomes a legal document, and then it is sent to the FAA National Flight Data Center or NFDC within the FAA in Washington, D.C., 800 Independence Avenue, where then it is released for the official distribution as a public instrument approach procedure chart, and that piece of information is then picked up by charting agencies, such as ourselves, and NOS gets it at the same time as well as Air Ad and other charting agencies.

What you're looking at here is the actual FAA Form 8260-3 for the ILS Runway 6 left approach at Agana. The part that you see highlighted in red here is very, very important. This FAA Form 8260-3 is actually an FAR Part 97.29. This is now a legal document. It's within the Federal Register. It's a Federal Aviation Regulation, and any changes that are made to it have to go through a legal process to do that.

Look at some of the pieces of it. If you look at the top, as you remember from the approach chart that you looked at earlier, the DME arch is an example. Go up into the top portion of the 8260 that show the altitudes, the beginning and the ending of the DME arch segment.

The next block at the bottom has all of the information that's applicable for the final approach segment, where it starts, what its altitudes are, glide scope angle and so forth, and then the minimums actually specify how low the airplane is authorized to go while it is still in instrument meteorological conditions.

There's also additional flight data in the lower right-hand corner that gives us information, such as DME required or simultaneous reception or whatever type of note that's applicable. In addition to that, there are obstacles that are included when the instrument approach procedure specialist deems that it's appropriate that an obstacle be placed on to the instrument approach chart, it's noted in this area.

One of the things that I think is very, very important to recognize, and what I'm calling a distinction, what you have seen now is the development of an instrument approach procedure.

As of this moment, there still is no instrument approach chart. The chart does not happen until the government officially releases the instrument approach procedure. So, my third line that you can see down there says "an approach procedure is not the same as an approach chart".

The procedure is the -- what the pilot flies from a procedural standpoint. The chart is what's used in order to depict what the pilot actually does. The distinction here is the FAA or other governments create the instrument approach procedures, whereas Jeppesen, NOS, Air Ad, Swiss Aire, and so forth actually then produce instrument approach charts.

One of the things that you saw at the beginning that Mr. Feith had requested that I give to you are some of the sources of the information that's there and where those pieces come from, and as you look at this illustration here, Agana ILS is shown at the bottom, just atop that chart, but you can see through the -- I don't know how well this is -- it doesn't read quite as clearly as what I would like to.

So, I will read some of these to you. Every approach procedure, you can see that the FAA Form 8260-3 is one segment of that entire approach chart. That's one piece of it. In addition to that, the intersections and their formations come from the NFDC fix list. The components out minimums come from the TERPS criteria. The Jeppesen speed and descent rate calculations, which are the time, speed and distance box, are additional pieces. The special use air space come from air space dockets. The holding patterns come from different documents. The communications come through the National Flight Data Center in the NIFDIs.

The obstacles come from the NOS sources as well as do the terrain, and, additionally, some of the terrain, the digital terrain elevation data and the approach lights come from a completely different source for us to know that there are approach lights available at an airport.

What I would like to do now is to show you some of those official sources that are used as the input into the approach chart, and what you're looking at here is the National Flight Data Digest published by the FAA through their National Flight Data Center, and this is for a date that's effective 7 -- it's a NIFDI that was released on July 25th, 1996, and it says in here distances are magnetic, distances are nautical and so forth, Azimuths are magnetic, and then effective on October 10th, and that's the information, and the details of that down here show that for Guam, I have two illustrations up here, for Guam, the flake intersection, which you saw as a note for one of the initial approach fixes for that instrument approach chart, actually is designed here.

It's been modified from a previous depiction or specification of how it's constructed, that in this case, you can see that it's from the UNZ or Nimitz Vortac 241.04 degree radio at 7.00 nautical miles, and its latitude and its longitude, and in this particular case, the FAA says that this flake intersection is to be charted on the instrument approach procedure chart, which means that you will not find that same intersection on any of the SIDS or STARS, if they were there, or the en route or area charts.

The communications which are on the chart that are at the top of the approach chart with one series of communications and the top of the airport chart for another series, these are a series of entries that we have created from source, and you can see that the NIFDI, which is the National Flight Data Digest 145, that was issued July 28th, 1995, in the com section of the Pacific area shows that Agana, Guam, International Airport, the ground frequency of 119.0 is changed to 121.9.

So, you can see in here that the chart that was current at the time of the accident shows a ground control is 121.9, and also over here, it's 121.9, and that's because of what the FAA issued through the National Flight Data Digest.

In addition, in July of '95, the ATIS or Automatic Terminal Information Service, was also added on a frequency of 119.0. So, you can see the frequencies of ATIS 119.0 on both of them. So, this is how the communications that are created at an airport get into the system to ensure that that's available to all the producers of charts.

The minimums that are on the chart themselves actually come from the FAA Form 8260, which includes the visibility, and since there's no runway visual range or RVR, they're expressed in miles rather than in feet, but there also are a couple components out minimums in here.

This is the runway alignment indicator lights or approach lighting system. I one of those are out, the visibility goes up to three-quarters. So, in this case, the minimums for the components out are stated in Sections 3 and 4 of the TERPS, and there's also -- whether there's glide scope availability changes the minimums, of course, becomes -- now becomes a localizer approach and approach light availability, and the content of 8260-3 is where the approach content actually is derived.

The obstacles that you heard Mr. Henderson talk about earlier are the bases on which the instrument approach procedure altitudes are created and also the optimum paths that are there, and you heard him tell why the procedure turn was not there on this approach, and it has to do with the obstacles.

In order to create the instrument approach with the obstacles that are there, that comes from a number of sources, and what we do to pick up those sources is that we create a digitizing capability off of a number of sources.

Primarily what we see here are operational navigation charts, topographical pilot charts, sectional aeronautical charts, world aeronautical charts, AIPs or aeronautical information publications, and also 8260.

So, this represents all of the obstacles that are significant on the island of Guam, and this -- these are from the Hawaiian sectional chart that's dated '97. In the lower right-hand corner over here, you can see there's a final approach segment controlling obstacle as well as a 724-foot antenna which is at this latitude-longitude, and that's why when you look on the chart itself, you will see an altitude of 724 feet depicted on the chart just next to the VOR location.

The terrain depiction, and you heard this morning from Captain Woodburn that there are a couple different ways of doing depiction on, whether it's color or black and white or green or brown, and a lot of variations, and what we have decided to do, because of the flight tests that we conducted, is to do those in brown.

We did a whole series of flight tests with about six different airlines in simulators in all different kinds of light conditions, and we -- when we first decided to put terrain on the chart, we had a number of samples that were in both green, and we did samples that were also in brown, and my personal preference was going to be green because I like the color green. I don't think it was so strong with the other things that are on the chart.

It's kind of interesting how wrong you can be proved when you give it to a number of pilots in a controlled environment where we had human factor specialists that were running the tests, and the pilots came back overwhelmingly in favor of the brown color, and when we asked why, the overwhelming answer is that brown scares me, green is pastoral.

So, that's the reasonwhy we went to the brown color, and as you know from Captain Woodburn this morning, that that is also the criteria within the ICAO Annex 4 for terrain contours when it's actual ground, but it was very interesting to have that validated through human factors tests with actual pilots flying it, that they decided that the brown was the better of the two colors.

The criteria for when terrain goes on because one of the questions probably has come up in your mind, is why the Agana ILS 6 left approach did not have terrain, and that's because through the agreements that we've had with our airlines, seminars in the airline community, as well as a lot of the general aviation input, is that there should be a criteria because you don't want terrain to be on all charts, you want it there when it's significant.

So, the definition of significant is difficult to come by, but where we drew our line is we said that in order for terrain to be on a chart, there needs to be at least one elevation that's 4,000 feet or greater above the airport in at least one planned view of the airport or if there's one elevation that's 2,000 feet above the airport within six miles, then once we do that, then every one of the contour lines, they start at the nearest 1,000 feet to the airport elevation, and then they are at 1,000-foot intervals all the way up to the top altitude that's depicted.

It also -- you'll find some of the charts that we have, if there's been a special customer request that says we would like terrain on here because it's a special airport for us, and then we will do that as well.

It's important to know that there are many sources for the terrain information. Some of that's digital terrain elevation data that comes from the military, but as you heard said before, that from Don Bateman, that the availability of the volume and detail of that is still considered to be secret by a lot of militaries, and that information really needs to come out in the -- in the public, we believe.

In addition to the digital terrain, we also use sectional charts and topographical charts as the basis for where the terrain comes from. Special areas prohibited alert and so forth, those come from special documents.

Just south of the Guam Airport is a military warning area called W-5.17, and you can see in the upper part of the illustration here, that these are the boundaries of that 5.17, and then there are the Class D air space or other air spaces around. Every one of those come from a different set of dockets that are released officially by the -- by the FAA.

The airport lighting. What's interesting about this airport and a bit unusual is that it was converted from a military to a civilian airport, and the military is also a bit stingy on how they release their information. So, we picked up all of our first information for the lighting of the airport from the airport facility directory or the FLIP, and then from that point, any revisions, once it goes into the official FAA system, then the National Flight Data Center is responsible for issuing additional NIFDI items.

So, the approach lights for Runway 6 left off the end of the runway that you can see in the planned view illustration as well as the airport diagram that have all the different kinds of lights here come from in this case the airport facility directory and will be updated by the National Flight Data Center.

Conversion table, which is at the bottom, the three-degree angle is specified, and you saw Bill Henderson talk earlier about that value on the 8260. From that information and that he specifies that the distance from the final approach fix to the missed approach point is 4.4 nautical miles.

With those two values, then we can compute for the pilot use at various air speeds that he may fly the approach, what his descent rate would be in feet per minute as well as the timing from the non-precision final approach fix to the missed approach point.

One of the things that's important is that once you get something out in the field, it never stays current because there's always changes that are going on, and the revisions to the procedures come to us from many different sources, and you can see here the National Flight Data Center is usually the releasing authority for the changes which will be by 8260, changes or could be communications or notes, and here's an actual change that we just processed the chart last month, and you can see our date stamp on here for February 3rd, 1998, because there is now a note that went on to the Guam chart, and it says here to add the note "localizer minimums require simultaneous reception of IGUM", which is the localizer, "and the Nimitz Vortac."

So, the simultaneous reception discussion which you heard Bill talk about a few minutes ago, there's now revision to the chart that is now out in the field as the current chart that has a February 28th revision date on it because of this change that went out February 3rd. So, that's a -- if you look at the chart that's in the field today, the simultaneous reception note is now on that chart.

Just as a reminder, one of the important things we're talking about now so far just the FAA, there are over a 190 countries throughout the world, and, so, this is only one of the many. We also get source information from Korea for all the airports that are in the Korean air space, and all the other countries throughout the world that require charting for instrument approach procedures.

Question is how we design a chart, and I'll not spend much time on here, but it's important, first of all, Captain Jeppesen, who was an airline pilot for United Airlines, started this in 1934, and there is a department which we call the Flight Information Design Department, that includes pilots and flight instructors as well as former controllers and chart experts and cartographers who are responsible for the design, but very important is the next bullet up from the bottom here, what we call our Jeppesen Listens Comment Cards.

They're a blue color, so our people inside call them the Blue Cards, but what these are is comments that come back from the customer to say why don't you do this or would you do that or I would suggest this or I saw this, and if you would have done it this way, which is a very valuable input, it's a feedback loop from the actual end user, followed by chart seminars that we have been conducting for years, in addition to the airline seminars, which every three years, we get all of our airline customers together in a room for about four days and go over the proposals, and it's based on the proposals that we have created for the designs of which the airlines then make a decision on which direction that we should be doing with our charting specifications. That bottom bullet is a very, very important part because it's the user who really drives what needs to be done from a charting standpoint.

A couple things to look at, and as you look at the design of a chart, I'd like to start it from two different approaches. One is from the smallest detail, and then also from the highest overview, and the smallest detail, what's interesting is if you look at this number right here, it looks like it's a 215, and if you use a normal PC with a font, you'll see that that's 215.

The reality is that's the identifier for the Rand Tool Illinois Airport, and the identifier is 2I5. It is not 215. So, from the smallest detail, we have created our own font. We do not use a standard font for the charts. We create a font that has the seraphs on the I's so that the pilot can tell that's a 2I5 rather than a 215, and also this is very interesting because this is from Captain Jeppesen about six years ago.

He said to me, "Jim, I got an idea now, why don't you do it?" And what he was suggesting because the 3, if you put a line on the front side of that, it can be very easily confused with the Number 8. He said, "If you put a bar across the top of it, you'll never get it confused with a Number 8." So, we have all of our 3s that have this shape of number, you can see the 3 here, the 3 here, and the 3 here, but where it's really important is when it's a latitude-longitude on a chart that gets close to another element that's on the chart.

That's the detail level, but from the highest overview, it's very important to recognize the design of the Jeppesen charts are based on the intended use, which is by experienced instrument-rated pilots. So, we assume that the pilot has his instrument rating or ATP and is a certified pilot.

Without human factors, a lot of the things that we do would not really come up the way that they should because the human factors experts find a lot of things that we, that are so close to it, don't find.

The Volpe National Transportation System Center has done a lot of human factors work on our charts with us, and the FAA sponsored a program which is a human factors program conducted by Dr. Bill Connor and Jill Cox, which did a complete human factors. There are numerous flight and simulator tests. Boeing has sponsored a study of what the pilot's eyes do when they look at the approach charts.

The ATA Charting andData Display Task Force has been doing a lot of work from a human factors that do flight tests of the actual changes that are recommended, and at the bottom is an important effort that was initiated because of an NTSB recommendation a couple years ago of a new task force called the ATA Charts Database and Avionics Harmonization Task Force, which really looks at the human factors of what all information a pilot has to look at and where they should be the same and where they cannot be, how do you go about training the pilot to understand where those differences are. It's a very important education thing for everybody that's involved in the system.

We just introduced a new briefing strip, and what's important about the approach to this concept is that it was in prototype use actually out in the field in the pilots' hands that were their charts to be used for a period of about two years.

We received literally more than 4,000 pilot surveys, had to hire a couple people just to do the analysis of the surveys, but based on the surveys, we released a new format that was in September of last year, and everything that you see here, which is known as a briefing strip, is a result of a very large effort that was mostly human factors driven by actual flight tests of pilots in simulators followed by the pilots in the airplane that did the test, and the responses back that we got were very, very good and caused us to change some things.

A very subtle little change in here is that we put our logo right in the middle of the chart at the top because that used to have communications in there, and the pilots were complaining because the clipboard on the control yoke of the airplane was covering up important stuff. So, now we put the Jeppesen logo up there, and they get to cover our logo.

In addition to that, one of the latest changes is what we are using as missed approach icons, and again a series of flight tests that said when you do the missed approach, the first thing that you do is climb straight ahead to 5,800 feet, and it also has the type of approach lights that the pilot should expect when he lands out from underneath on the approach as he's approaching the airport. These are the lights that he should be looking for. So, it's another aid from a human factors standpoint, so that if he breaks out underneath and doesn't see this, he's got another check for what he should be looking for.

The question about how often pilots go into airports and what they do for the first time resulted in a new design that we came up with called airport qualification charts, and this is a whole series of charts for all the airports throughout the world that are the very difficult, challenging airports of which Agana is one of those, and this is one chart out of the series that goes through the details from a pilot briefing standpoint, so that they know specifically the kind of things to look at in a challenging airport, and this is one of the designs that came out of some of our human factors efforts that we did.

Now going to the third bullet of the outline, the overall bigger unit, and that's the validation of source, and two things that I think are very, very important for us all to understand is that, Number 1, is that every FAA approach procedure is FAR Part 97 and is technically illegal for us to make a change. It is not Jeppesen's job to go in and make a change to an FAR.

What we do is if we find problems, then we go back to the FAA, and then they re-issue it because they're the only authority that can release and change FARs. That same thing is true for every international approach procedure that's included in each one of the state sovereign domains. So, the right of the content belongs to the government and not to us or to the chart-maker and that makes a difference in how we do the changes.

What's important is if there are obvious errors, we seek clarification from the authorities on any element that appears questionable as a result of routinely processing the procedure for publication in graphic form. So, those things which we spot that say uh-oh, if they're obvious, we'll send them back or if we find them for any reason, we send them back for clarification.

One of the things that's also important is we make no attempt to determine that the procedures prescribed by the governing authorities are in compliance with their own criteria. I think one of the questions which you heard asked by Mr. Misencik a little while ago to Mr. Henderson is were there any waivers that were issued against this instrument approach procedure. That's one of the questions that we would not know the answer to, and it could be that there is a waiver that's applied to it, and we would not know it.

We do not go in and check if the government's in compliance with their own criteria, either through criteria that they have made or changed or waivers. So, that's really the authority of the government on their own criteria.

However, one of the things that we do do is we enter all of the instrument approach procedures into the navigation database, into a very large computer database, as a way to validate a lot of the pieces of information that are on the approach chart itself. Those kinds of things, I won't go through the detail of this very complicated chart, but just to let you know there's a very large structure on how all these pieces connect together. When I say pieces, I'm talking about VORs, NDBs, airways, instrument approach procedures, final approach courses, the locations, the latitude-longitude. All of those are entered into a database, and the information as I want to show you one example that we use for an edit, we do a bearing and distance edit, so that for the location on this approach procedure is an example of the location of the outer marker, the Nimitz VOR, the end of the runway, the fixes, the initial approach fixes, an example.

We take the values that Mr. Henderson would have put on his 8260-3. We take every one of those pieces of information that he has put in there, and we take that and put it into a database and do a calculation. So, if he says the bearing is 06 -- six degrees is an example, we'd go in, and we'd compute it to be 063 degrees. We say oops, and we have a validation to -- to check that.

So, this is how we check against the source, and the kinds of things that we find, these -- from one bearing and distance calculation between two fixes, these are all the things that we are able to check in that one calculation.

In addition to that, all of the charts are created out of a database, so that when the instrument approach procedure chart is actually generated into a graphic picture, that that picture, if there's anything that was in the database that's incorrect, a lot of the things that you will never find by editing lots of text, you will find immediately obvious as you have those show up on a screen in the wrong location.

So, our computer graphic visual edits, as we create the chart, are kinds of things that are beyond which we talked about earlier that go into the database for those validation, and since we use the database for chart production, if we find an airway that actually has a misalignment in it, we find by drawing a straight line how much misalignment there's there, and the graphic placement from the database actually sticks it there, and this is done for every place throughout the world, and there are a number of geographical locations. If something's not co-located or something's on top of each other, and one of the things that you've noticed in the approach is that flake intersection and the initial approach fix on the localizer are very close together. Those pop up and show up very graphically when you're looking at the charts and the creation of that.

The -- we have also an agreement with a number of programmers with our -- we have formed a venture with the Russian AIS Government for their aeronautical information, and we're using those programmers that have created an editing tool where every piece of information that goes into the database, we have a chance to visually edit that, which checks paths, but it's important to know what things are checked, but it's probably as important or maybe even more important to know what's not checked.

We do not check any obstacles because the obstacles are not in there on the database. We do not check the procedure validity. So, if the -- if Bill decided not to put a procedure turn in there, we don't check to see that Bill should have or should not have put in a procedure turn because we assume that he knew what he was doing.

We also do not check the MDAs or the segment altitudes against the obstacles or terrain because I think you heard Mr. Henderson say as an example, there was an obstacle that changed the MDA from a 560 to a 580 back to a 560, and there's no way that a chart producer would have any knowledge of that kind of information that's going on out in the field, and we do not check compliance with the TERPS or the PANS OPS.

This -- I have a demonstration, but I think because the time is getting a little bit long, I won't go through the demo, but this is an actual graphic that I lifted from the editing tool, and you can see on here, if I would have pressed this button, you would have seen the DME arch on here as well, but what this does is it shows the lay-out of the instrument approach procedure that comes from the initial approach fix that's very close but slightly adjacent to the missed approach track.

So, flake and the initial approach fix are very close together, but they are not at the same place, and the holding pattern out of flake is drawn this very large because it's shown to the scale of an airplane that's flying about, I think it is, 200 knots, and then the actual missed approach that goes up and makes a right turn till it does a capture to the fixed coming in-bound to the -- or out-bound from the radial, from the VOR, that physically forms the -- the flake intersection.

Okay. Mr. Feith, that's the end of my formal part of my presentation.

MR. FEITH: Thank you, Mr. Terpstra. That was very informative. It clears up a lot of questions from the standpoint of who's responsible for -- for the actual procedure versus charting.

Can we bring the lights up, please? The -- I'll give you an opportunity. I know that you just touched on it briefly with the terrain, but Captain Woodburn talked about how they on the one chart that he showed this morning shows a minimum safe altitude over terrain versus Jep, who shows the actual terrain elevations.

Do you have any opinion on which -- which charting is better, worse, any --

THE WITNESS: Well, I think it's important, first, to recognize, as Captain Woodburn said, is that, first of all, the most important part is that terrain is actually there. The terrain depiction, we started in 1975. So, we've been doing it not quite as long as British Airways but for about 23 years, and we started out by using the minimum altitude, minimum safe altitude, which we call the area minimum altitude, and also did it in green.

So, we started that way as a recommendation from the airlines on the direction that we go and applied that on the area charts first but not on the approach charts.

As we started to create some changes to what we wanted to put on the approach charts, we tried to make some decisions on which direction we were going to go. We have approximately 30,000 different instrument approach procedures that we publish at Jeppesen, and one of the things that we're very careful to do is to make sure that we do enough samples so that we have a method that will work every place.

One of our favorite sayings is one robin does not a spring make. You can't use one example and apply it to everything.

What we did is we found that the application of the area minimum altitude in many cases actually was higher than segment altitude, and we -- we were concerned that if a pilot flew the actual instrument approach procedure as published by the government, in some cases, the minimum safe altitudes were actually higher than those altitudes, and now you've put the pilot in a dilemma of which altitude you actually should be using, the one that's part of the instrument approach procedure published by the government or whether you ought to use the minimum safe altitudes.

As a result, we made the decision to go to contours and create the actual contours on the ground. When we did that, it also presented us with a new dilemma. We now have the area minimum altitudes in green on the area charts, and contours in brown on the approach charts, and the human factors there are really not good, and we decided as a result of the differences between the two, it's best to be one way, and we felt that the contours were the better of the two, and as a result of that effort that we had done and the human factors that we had done with the pilots actually flying them, we ended up converting everything to brown.

The other part that's of a concern to me is that the minimum altitudes are not legal altitudes for pilots to be flying, and those altitudes that are on there are nice to tell you what the buffer is, but the reality is, is that there are FARs that say a pilot is not authorized to create his own minimum altitudes, and he should not be using those altitudes. He should actually be flying the altitudes as prescribed by the instrument approach procedure and whatever the vectors are given to him by air traffic control.

So, those are the reasons why we went to actual contours with the brown color on not only the approach charts but also on the area charts. Different philosophy. Neither one of them are perfect, but the best thing is that the information is there, so that the pilot has an awareness, and as you can see on both the British Airways presentation and our presentation, the higher altitude, the darker the color. It starts out with a lighter color and goes to a darker color. So, the pilot has an immediate cognitive recognition of the change, so that he can see what it is without really having to look at numbers.

MR. FEITH: Thank you. Teddy, will you do me a favor and please put up the approach plate real quickly?

With regard to terrain and terrain depiction on an approach plate, and slide it up to the profile, Teddy, please, given the fact that the VOR sits up on top of the hill looking at this, it's basically flat plate.

Has there been any attempt or should there be any attempt to depict terrain, especially when it comes to mountainous terrain or -- or high obstacles along the approach corridor on this part of the approach plate, so that a pilot knows that they are in an area of high terrain in the area of the step-downs for this approach?

THE WITNESS: We have done quite a few studies in order to determine whether the feasibility of terrain in the profile view would actually be able. There -- we have actually presented these even at airline seminars to determine what should be done.

We came to the conclusion that they should not be done for a number of reasons. Number 1 is that the profile view is not drawn to scale, and the reason it's not drawn to scale is because some profile views may encompass a total area of maybe five miles. Some profile views may be 30 and 40 miles long. If you do the entire profile view to scale, if it's a very long one, all the real critical information, which is in the five -- last five miles, gets so tight together that you really lose the ability to present the information in the form that's helpful to the pilot. That's one of the factors.

The other -- another factor with it is the decision on which profile to use, whether you should use the terrain profile right down the very center of that line or whether you should use the profile that encompasses a wider area. It's not determined which of the two are better and which one should be done. So, that's a complexity there as well.

The other thing is it's really not been determined that the addition of that information really is that beneficial. We found that in the planned view, that has been very much of an assistance, but I think there are better ways to solve the problem of descent profile in the profile view rather than applying the terrain.

We should look at it again, but those are the reasons why they have not been done.

MR. FEITH: You had spoken during your presentation that, of course, Jep is not the only chart vendor. Of the numerous chart vendors out there around the world, do you all interact, talk to each other, to try and come up with some of the common problems amongst the charting vendors and eliminate some of those problems or some of the interpretation confusion that may exist?

THE WITNESS: Yes, we do, in a couple different ways. Number 1, there's an ICAO meeting that's being held this week, which I will leave tonight to get there by next day or two, that's for two weeks, an ICAO, to deal with these exact same issues.

Also, within the United States, there is an FAA/industry aeronautical charting forum which is attended by FAA personnel as well as military charting and Jeppesen and NOS, to determine any differences that are there and what we can do about them.

Also, there's an SAE G-10 charting committee that's chaired by Captain Young, who's with us today, where we also deal with these issues with cross cultures.

In some of the international forums, we are dealing with Transport Canada and also to some extent with Swiss Aire, but we have not had much participation with -- by Air Ad and SAS and some of those.

MR. FEITH: With regard to the charting, this is, of course, a precision approach that where we lost the -- the glide scope, it now becomes basically a non-precision approach.

Are there any efforts right now by the industry or specific airlines to try and rectify, given the fact that we have two different sets of minimums, any better guidance to a pilot when we do lose the precision part of the approach?

THE WITNESS: There are a lot of things that are going on at the moment that are going to provide a lot of assistance to this. One of the things that's significant about Change 17 to the TERPS criteria is that the FAA has decided that they are going to publish the vertical angles on the 8260 for the non-precision paths down on the final approach segment.

There are some holes that they need to fix in that, but that's one of the major efforts that's going on, and one of the things that's as a result of FAA participating in the RTCA efforts and some of the other efforts, the industry coordination efforts that are going on. So, within the FAA community, the TERPS Criteria Change 17 does add a vertical component as well as an evaluation of the obstructions below the MDA.

In addition to that, Jim Gregory of Transport Canada is the chairman of the ICAO Obstacle Clearance Panel, and they are meeting this week in Brazil to come up with the same criteria for applying a non-precision path for non-precision approaches in the ICAO standards.

MR. FEITH: And let me just make one point real quick. This is, of course, a paper-produced approach plate, but we do have this kind of criteria also programmed into some of the newer-generation airplanes in the FMS system.

Are there any efforts right now to program in minimum criteria for non-precision approaches where -- what's the best way I can ask this? Where the precision approach information is in the FMS, but if there's -- if you lose the precision like in this one, where we've lost the glide scope, the non-precision minimums are also in the FMS?

THE WITNESS: There are two things that are going on right now with a couple lead carriers doing the largest share of the work, and it's U.S. Airways and Northwest Airlines, and both of them are -- they have the VNAV or the vertical navigation path into their FMSs, and both of those systems, all the FMS databases in the world now currently have the VNAV path for the final approach segment coded into the database.

What U.S. Airways is in the process of doing is creating an approach concept within their industry that says an approach is an approach is an approach, and it doesn't matter whether it's a precision approach or non-precision approach, if we've flown exactly the same way using a descent path, that is a final descent that goes right down to the runway threshold.

Northwest Airlines will be starting probably in the next month or two to start putting all the localizer non-precision approaches into their database, so they will always have the vertical path for their localizer-only approaches in their databases.

MR. FEITH: So, that basically goes along with some of the comments that Captain Woodburn had talked about, about standardizing all approaches and using the autopilot on as many approaches as possible to reduce workload. This would do --

THE WITNESS: Yes, this is correct. I think as a result of the non-precision approach accidents that have been happening over the last three or four years and the technology that's now here, the airlines are recognizing that they need to be doing this and are now starting to create an environment where all the approach procedures will be flown essentially the same regardless whether they're precision or non-precision.

MR. FEITH: One last question for you, and this is my softball question to you. Is there anything that, based on what you've learned through us and this accident, is there anything that you believe that we, the NTSB, the FAA or the industry, should be doing to improve safety from the standpoint of charting instrument procedures, giving pilots better tools?

THE WITNESS: Well, there are some new tools out there that have VNAV capability and electronic ability. Right now, there is really no back-up if you look at the classic airplanes. There is no back-up when the glide scope is gone. It's strictly fly over fixes at pre-specified altitudes and do a series of steps that are coming down.

If you have a -- with the new generation systems, where the vertical portions are certified for approach capability, the vertical portion is in there as a back-up. So, if the glide scope is gone, there is a secondary VNAC electronic path to glide the pilot down to -- to final, and I think that capability, the more that that's initiated within the industry, the better off we are.

There are some problems with some of the previous FMSs that may not have quite the level of integrity of getting that accomplished. So, that's an issue that also needs to be dealt with.

MR. FEITH: Thank you, Mr. Terpstra. I appreciate your time. Do you have any questions, Paul?

We have no further questions, Mr. Chairman.

CHAIRMAN FRANCIS: FAA?

MR. DONNER: Thank you, Mr. Chairman. No questions.

CHAIRMAN FRANCIS: NATCA?

MR. MOTE: Thank you, Mr. Chairman. No questions.

CHAIRMAN FRANCIS: Guam?

MR. DERVISH: Thank you. No questions.

CHAIRMAN FRANCIS: Korean Air?

CAPTAIN KIM: Thank you. No questions.

CHAIRMAN FRANCIS: Barton?

MR. EDWARD MONTGOMERY: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: Boeing Company?

MR. DARCEY: No questions, Mr. Chairman.

CHAIRMAN FRANCIS: KCAB?

MR. LEE: Thank you, Chairman. One question.

Regarding this Jeppesen manual, how do you locate the non-precision procedure? Altitude, descent, procedure is indicated as one of the step-down methods.

Given that, the manual published by the FAA indicates that it is supposed to be the constant descent. Is there any particular reason as to this discrepancy or the difference between the Jeppesen material and the FAA data?

THE WITNESS: You ask a very good question. The reason for the depiction that we have and, by the way, the NOS depiction or the U.S. Government charting depiction shows a constant rate, but by definition, that is not a constant rate of descent the way it's designed.

The way the approach procedure is designed at Guam, there are numerous altitudes at different fixes that are not on a constant descent rate. By showing the profile view and the manner in which it is, it shows that the altitudes that are each one of the fixes are the ones that are to be maintained until the fix is actually passed.

Because the approach procedure as is designed on a non-precision, you cannot fly a constant straight line all the way down and make all the altitudes and fixes work.

MR. LEE: Thank you very much. That's it.

CHAIRMAN FRANCIS: Do you have a further question?

MR. FEITH: Well, I just want to follow up on -- you just made a comment, Jim, about that you can't make a constant rate of descent work on this step-down. Am I understanding you correctly?

THE WITNESS: Yeah. The way that most instrument approach procedures are designed, that you cannot start at an altitude and follow a constant rate of descent all the way down to the runway and make all of the altitudes work at the exact fixes. It just doesn't work.

MR. FEITH: Why -- why is that?

THE WITNESS: Because the criteria that's used by both the TERPS criteria as well as the PANS OPS have a policy in most cases that the altitude that's prescribed at each one of the fixes in the approach procedure will be the absolute minimum altitude that will have the required obstruction clearance as specified in the previous segment.

As a result of those -- as a result of that criteria, each of those altitudes is the minimum altitude, and when you build your criteria that way, you don't build your criteria for constant descent rate, and that's one of the issues that really needs to be addressed by the FAA, and if you look at the approach procedures around the world that also should be addressed by the PANS OPS, that there needs to be a criteria that says that the fixes that are on a non-precision final approach segment should always be at locations with altitudes that are consistent with a straight line.

There are probably six or seven governments throughout the world that do that, and in those cases where there's a constant non-precision descent rate specified by the government source, and Germany does a number of these, then we produce a non-precision constant rate descent, but until the governments actually specify the altitudes that are appropriate for a constant descent rate, that's not the way those approaches can be flown and match all your altitudes with your fixes on the way down.

MR. FEITH: Well, given the fact that the last couple of days, we've been talking about constant rate descents with Paul talking about it a little earlier to standardize those types of approaches, and the fact when we were talking to Korean Air, the management pilots, talking about how some of their crews do in fact fly these constant rate descents for passenger comfort, you're telling us basically you can't do it.

THE WITNESS: That's correct. And my belief is that there needs to be a new criteria established for non-precision approaches, and the ICAO has done that in some cases as a recommendation, and Germany -- I wish I had some of those here, but I would show you that what a number of the governments have done is they have specified non-precision constant rates of descent, and what they do is they have a straight line that goes all the way down on a stabilized descent, and every one of the fixes that are on there that are limitation fixes because of the altitudes that are there, the distances and the altitudes are adjusted so that as you hit each one of the steps, the apex of each one of these steps is on a straight line down.

FAA does not design the non-precision approaches that way. That needs to be changed.

CHAIRMAN FRANCIS: Can they be legally flown, Jim, without those changes? I mean if -- if you -- if you pick the highest of -- of the fixes and then accept the fact that some of them, you're going to be higher than the minimal, can't you fly your own constant?

THE WITNESS: Yes, and, Bob, what you bring up is a very good flight technique in order to accomplish that, but my feeling is that that -- the criteria by which that's done, even though you can do that now, that criteria ought to be created as the basis from which the non-precision approaches are flown.

The -- what we have done in our database is exactly what you've talked about. In the database, there is a non-precision vertical path that goes down to 50 feet above the runway threshold that has a line that projects all the way up that goes at or above each one of these fixes on the way out to where the approach starts. So, there is a way to get that accomplished, but I consider that to be a work-around to the real solution on the long-term basis.

CHAIRMAN FRANCIS: Which is to -- which is to -- to standardize it efficiently?

THE WITNESS: Yes.

CHAIRMAN FRANCIS: Okay. Greg?

MR. FEITH: Plus, that would also mean that you'd have to establish some point in space where you start that -- that procedure on a non-precision approach --

THE WITNESS: Yes.

MR. FEITH: -- so that you hit all of those steps at those minimum points?

THE WITNESS: And that can be as it is today, either at the final approach fix or further out on the approach, depending on the traffic that's in the area, but that's why I had mentioned there's a basic philosophy within the FAA and other governments today that each of the altitudes are absolute minimum altitudes, and they're not really operational altitudes. They should be changed to operational altitudes.

Some of the approach paths today are as shallow as one and a half degrees, and they -- you can't fly a 747 at one and a half degrees. They should be up to a nominal three-degree descent.

MR. FEITH: Well, that was my next question. Will -- will a standard like that apply to all types of aircraft?

THE WITNESS: It -- it should because currently, today, the ILS default or the standard descent rate on an ILS glide scope today is three degrees or roughly 300 feet per nautical mile, and that works very well for almost any size of airplane, and once you've defined that as the standard for precision, that can also be applied to the standard for non-precision as adjusted for obstacles in the final.

MR. FEITH: One last question. We know that there are some airports, though, that do on their precision approaches have a steeper than three degree glide scope.

THE WITNESS: Yes.

MR. FEITH: And there are some that have less than three-degree glide scope, depending on -- I mean they're pretty close, but --

THE WITNESS: The military still has a number of ILS glide scopes that are 2.5 degrees. Almost all of the U.S. ILS glide scopes by the FAA are at three degrees, and they will not go above 3.77 degrees, except by waiver, which is occasionally.

MR. FEITH: So, at those airports that have a greater than three degree glide scope, you'd have to make some sort of exception for your constant rate of descent non-precision type approach.

THE WITNESS: Well, but the exception is very easy because the information will be shown on the charts, so that you'd know what the descent rate is and the angle. So, that's -- as it currently is by looking at any ILS approach chart today, that information is there and could be on a non-precision approach.

MR. FEITH: Very good. Thank you, Mr. Terpstra.

CHAIRMAN FRANCIS: Pat?

MR. CARISEO: No questions.

CHAIRMAN FRANCIS: Mr. Berman has one question.

MR. BERMAN: Hello. Mr. Terpstra, if you'd just take another look at the approach chart for Runway 6 left at Agana. Teddy, can you put that up? Yeah.

I'd like to refer to the initial approach fix definition for flake, 063 degrees IGUM, and then in the next slide, it says ILS/D 7.0. Do you consider that that second line there might have an implication to a pilot that the ILS is the source of the DME information?

THE WITNESS: Not when you consider it's designed to be used by an experienced instrument pilot. The slash in there separates two lines. So, when you read that 063 degrees of IGUM ILS and then followed by that, the DME is from the UNZ VOR.

I mean there's always potential for mis-reading of any piece of information on a chart. That's always possible, but in this case, the slash between the two of them is the same as you see in the profile there to illustrate that same kind of differentiation.

MR. BERMAN: Hm-hmm. Is -- is or has Jeppesen given any consideration to the human factors of the line breaks on the charts?

THE WITNESS: We have done a lot of work with the human factors. With the line breaks like this, we've done some, but this has not been our largest area of concentration.

MR. BERMAN: Okay. Thanks.

CHAIRMAN FRANCIS: I think that's it, Jim. We appreciate your time and having come and missed some of Montreal. It's a sacrifice to have to stay in Honolulu instead of being in Montreal this time of year.

THE WITNESS: Thank you.

CHAIRMAN FRANCIS: Thanks.

(Whereupon, the witness was excused.)

CHAIRMAN FRANCIS: Our final witness is Captain Wallace Roberts from ALPA, if he could come up.

Whereupon,

CAPTAIN WALLACE ROBERTS

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

TESTIMONY OF CAPTAIN WALLACE ROBERTS

FORMER CHAIRMAN, ALPA CHIPS COMMITTEE

AIR LINE PILOTS ASSOCIATION (ALPA)

HERNDON, VIRGINIA

MR. SCHLEEDE: Captain Roberts, could you give us your full name and business address for our record?

THE WITNESS: My name is Wallace Roberts. I go by Wally. And my business address is Air Line Pilots Association, 535 Herndon Parkway, Herndon, Virginia.

MR. SCHLEEDE: And you work for the Air Line Pilots Association?

THE WITNESS: I am a retired TWA pilot, and when I was active, I was the first chairman of ALPA's Terminal Instrument Procedures Committee or, as you've heard the acronym, TERPS, and the name of the committee was changed later on to Charting and Instrument Procedures. For the last five years, since I retired, I've been assisting them in the TERPS areas.

MR. SCHLEEDE: Assisting ALPA with that?

THE WITNESS: Yes.

MR. SCHLEEDE: Okay. Captain Misencik will start the questioning.

CAPTAIN MISENCIK: Hello, Captain Wallace -- Captain Roberts. The -- could you give us an overview of the -- what the CHIPS Committee does?

THE WITNESS: The CHIPS Committee is active on several fronts, all relate to charting issues and TERPS issues. The two are quite different. TERPS, as you learned here from Mr. Henderson and Jim Terpstra, involves obstacle clearance and aircraft performance, nav system performance. Charting involves the issues of how the pilot reads their chart, and we're into new areas of flight management systems, lateral nav systems, space-based systems, and the door's open for new and wonderful things, but it requires that we do it on an evolutionary basis, and mind the store with the older airplanes that are going to be around a long time.

In that vein, we meet with the FAA on a regular basis. Jim mentioned the aeronautical charting form. The next one's coming up next month. We meet with the FAA, Air Force people and some industry users and discuss TERPS on a rather informal basis, and then on occasion, we request meetings or vice-versa and go down to Oklahoma City and meet not so much with Mr. Henderson's shop but more with the people that develop the criteria.

CAPTAIN MISENCIK: How long have you worked with the CHIPS and the TERPS committees?

THE WITNESS: I started doing -- I went to work with TWA as a pilot in 1964 and checked out as captain in 1967 and then started working with ALPA's national all-weather flying committee in 1970, and the chairman of the committee at the time decided we needed a TERPS committee, and I took that over in 1971 and worked as the chairman till 1976 and then assisted the committee after that time until the early '80s when I took a hiatus and worked in different ALPA work until I retired.

CAPTAIN MISENCIK: Were you involved in any other activities regarding aviation safety?

THE WITNESS: At the present time, I'm writing a monthly technical article for a newsletter that's designed for instrument-rated pilots called IFR Refresher distributed throughout the United States, and I guess throughout the world, and I write technical articles that are too technical for general aviation -- for general-type aviation publications, and they seem to be well received, and I maintain them on a Web site for people that want to see them after the fact.

I know they're read generally. I get a lot of feedback from Air Force instructor pilots that refer to them. I'm trying to get the word out in the more technical esoteric areas that are important that the FAA just is trying to get out there, but, you know, they have the manpower problems with getting out publications and how you do these things.

CAPTAIN MISENCIK: Captain Roberts, could you give us a brief description of what the purpose of instrument approach and procedure charts are?

THE WITNESS: I think that my friend Jim Terpstra did a pretty good job there. My just slightly different bent on it is that it started in 1930s with, I think, Jimmy Doolittle really did the first successful approach. It was called an instrument let-down, and that's literally what it is. To get out of the en route environment to a point where you can see the runway and land in poor weather conditions and safely avoid obstacles and being able to safely maneuver the airplane for landing without seeing out the window until you're quite near the runway generally, and we even have new systems now where they can land automatically without ever seeing the runway. Those are limited applications but nonetheless very important.

The air space required to fly an airplane on instrument so far has been far greater than is required when you're flying an airplane on a nice sunshiny day because you don't have the same cues. The pilot certainly cannot react as quickly.

CAPTAIN MISENCIK: In your opinion, are all of the -- we discussed all the considerations in designing and -- or developing and certifying approach construction, and in your opinion, are all the considerations motivated by safety?

THE WITNESS: I'm sorry. Would you --

CAPTAIN MISENCIK: I said in -- we're discussing chart approach procedure development. In your opinion, are all the considerations motivated by safety?

THE WITNESS: Not entirely, although I think that by far, -- I'm not familiar -- too familiar with how it's done in other countries, other than to know that not every country is as diligent as our country is.

I think the FAA does a commendable job overall. I think certain times, there are political considerations that force our friends in Bill Henderson's shop to design procedures that we might not rather see, like greatly offset localizers at places like Washington National or the approach at Kennedy is one that sticks out. Everybody that is really not a very good instrument approach.

By the same token, they're difficult to fly, but they're really quasi-visual approaches because the weather ones are higher, but they are approaches that pilots would rather not have in their manuals at all. But those are the minority.

I think that most of the places, especially major air carrier airports, where the terrain isn't a problem, in particular the FAA's done a pretty good job overall providing us with instrument landing systems.

CAPTAIN MISENCIK: We've been discussing the Guam ILS 6 left approach plate. Would you consider that -- how many different procedures are depicted on that chart?

THE WITNESS: Well, I -- I think I -- I have as good a handle on TERPS probably as any airline pilot out there, and -- and the chart has meant different things to me on different days.

With the glide scope working, the procedure is a very standard international ILS, except that it does require DMA in an indirect sense to fulfill the entry into the procedure of no radar vector and to complete the missed approach.

With the glide scope gone, and I heard Mr. Henderson testify, and he -- he opened -- he -- he lit up another light for me today. This is really not only a localizer procedure but it's a localizer DME procedure, and not only is it that, it's a localizer DME VOR procedure, and in many ICAO countries, I suspect that's exactly what the title would say. It would say ILS DME VOR, and -- and maybe that would serve pilots better in an oddball location like this to be a real heads-up. You've got something here that's a little different than you're used to at most locations.

CAPTAIN MISENCIK: Well, before we get your comments on the -- the design of this particular approach, could you tell us, in your experience, how many non-precision approaches an airline pilot would expect to perform in the course of a year?

THE WITNESS: That would depend upon the airline. If you take a major national airline of the

United States, where this country has done a pretty good job overall providing ILSs at all our high-traffic airports, I heard a remark made by a management pilot at American Airlines shortly after one of their recent tragedies, that they surveyed their airline and found that the average American Airlines line pilot flew one non-precision approach a year.

My personal experience at TWA on the route structure that we had then, I flew domestic and out here to Honolulu, which is really domestic, also, that I might fly two or three non-precision approaches a year, not very many.

Now we get to the commuter airlines or to the Alaskan airlines folks, and they may shoot a lot -- quite a few non-precision approaches a year.

CAPTAIN MISENCIK: As an airline pilot and as a recognized expert on TERPS and charting, could you give us your impressions of the localizer approach into Guam and comment on the design of that particular approach?

THE WITNESS: It appears to be that the approach is probably the residual of a U.S. Navy design which I've assessed this procedure very carefully from a TERPS obstacle clearance standpoint, laid out the topographical maps and all. The procedure from an obstacle clearance standpoint is certainly full compliance with TERPS. There's a lot of options and procedures a specialist has in those areas to create a smooth-flowing approach for the pilot.

If you'll note, the VOR DME Runway 6 left has a rather different profile than the localizer procedure. That may not be necessary. If you can make them both the same, the TERPS is complied with in either case, but there's an extension of this flyability, and -- and I think when you get into these type of procedures, there's a missing link, and not only in the FAA but probably throughout most of the PANS OPS ICAO member nations that -- that the people flying the really heavy iron-like air carrier pilots and our Air Force friends flying C-145s and C-5s and these, their needs are not necessarily thought through when the flight inspection's being done in something like a Beechcraft King Aire.

CAPTAIN MISENCIK: In your opinion -- would you care to comment specifically on the localizer approach to Guam?

THE WITNESS: Well, if I were magically suddenly in charge of facilities at Guam based on what they had in position on the day of the accident, I'm not sure that I may have redone the -- attempted to redone the -- do the localizer procedure to make it a little more like the VOR procedure, VOR DME procedure, but that would require a DME fix similar to the 1.3 DME.

But what I would really be crying out to me is I got a facilities problem at this airport, and I'm going to correct it, and there's two things I would have pushed for real hard to change, and the most important one, which is important to airline pilots everywhere, is a frequency paired co-located ILS DME facility, so we don't have to rely upon the DME on the VOR, and we can get the VOR pretty much out of the picture, except we still need it to transition on to the procedure and for the missed approach.

But I can solve that problem by adding something that's contrary to the FAA policy today, but I'd put in an MDB at the outer marker, a compass locator, particularly since this is a remote island station, and I would create all kinds of flexibility now with all those facilities, and, further, I would seriously consider -- and this is something we're going to take up, is that a procedure this complicated should very possibly be on its own chart, and -- and that brings up the issue of even if localizer approaches are going to continue to be on ILS charts, in most cases, they probably should have their own title, and the controller should clear you for that localizer approach when he knows the glide scope -- or she knows the glide scope's out, and, further, there should be a note by that localizer procedure saying disregard glide scope indications, just as we have today on back course approaches.

CAPTAIN MISENCIK: What -- what inhibits those changes? Is that contrary to regulations now, having a localizer-only approach?

THE WITNESS: Well, no. Right now, if -- if the procedures specialist and his managers deemed it necessary, they'd be well within their prerogative today to pull it off and put it on a separate chart. But that's contrary to conservation of paper.

I mean if you did that everywhere, you would have -- people would be carrying hundreds of more charts around, and in most cases, it wouldn't be necessary. At this location, it's a judgment call. I would have judged to pull it off and put it on a separate piece of paper, but that doesn't mean the FAA did anything wrong by not doing that.

CAPTAIN MISENCIK: Regarding Guam, is it common procedure to have a step-down on the final approach segment?

THE WITNESS: Very common to have a step-down fix in a localizer procedure in the final approach segment, but this is the first time I've ever seen it be a VOR station, and -- and I think that that paragraph we talked about earlier, 288(c)(4)(c), would more properly have a minimum there.

I understand Bill's argument, though, that VOR is really required here, but the thing we have to remember is that our people sometimes elect not to split the cockpit because the captain only really has one VOR set, and the co-pilot has one, and they like to do the same thing whenever possible, and this is something that's not true in light airplanes or even military airplanes.

We cannot split our DMEs, and the policy is that both sides should be reading the same thing whenever possible. Therefore, to have the option of the higher minimums which result in a lot higher visibility minimums would -- with a crew additional flexibility to the procedure and also help the guy that shows up with just one VOR set. He's going to use it for the localizer in-bound, but then he doesn't miss, he can retune his VOR for the missed approach, and that guy's not taken care of by not having 1440 as a minimum.

CAPTAIN MISENCIK: How about the segment altitudes and the minimums? Do you consider them appropriate in this -- in this approach?

THE WITNESS: I'm sorry. Would you say that one more time?

CAPTAIN MISENCIK: I said the segment altitudes and the minimums --

THE WITNESS: Oh.

CAPTAIN MISENCIK: -- on the Guam approach, do you consider them appropriate?

THE WITNESS: Oh, I've evaluated the procedure. Everything's correct. Like I said, the -- whether you have 14 -- 1440 at the VOR is a lot higher than -- than is needed by criteria, but that's where the facility was, and the procedures specialist only has so much flexibility.

If he or she is electing to use that VOR station as a step-down, they're kind of married now to the altitude and the terrain out earlier in the approach. So, yes, the altitudes are appropriate, but -- but not as flexible as if I were using a localizer DME. I could do more things.

CAPTAIN MISENCIK: And would you care to comment on the notes on the approach plate? In your opinion, what was the intent of the DME-required note?

THE WITNESS: I -- I don't like the note. I've never seen a note like that before. Generally when DME is not in the title, it's because it's used as conditional, like radar or DME required. ADF or DME required for something other than the final approach segment.

It also brings out to me that we need the DNR work going the naming convention for the final approach segment has been in a state of controversy within the people that work in the U.S. TERPS community, and this cries out for the fact there's something wrong with the naming convention because we shouldn't end up with a note like this in my view.

If we do, it should become intuitively apparent to a pilot why that note's there, and that certainly is not the case.

CAPTAIN MISENCIK: Well, do you feel that note is unnecessary or incomplete or what exactly do you --

THE WITNESS: By putting it up inthe title, that note is necessary. You can't -- the note is necessary. I guess I would have to agree that maybe it is incomplete. I think that the air traffic facility at this location due to sparseness of nav aids should have committed to the fact they'll provide radar vectors with the terminal radar on demand, like most U.S. domestic facilities do. Then the note would have read radar or DME required at least for the approach plates, but we still have the missed approach problem.

But then we could have taken the missed approach back to the VOR like we did in the VOR alpha approach, and then we could have gotten away from the note DME required, and it would have been radar or DME required.

CAPTAIN MISENCIK: There's also a note DME from UNZ. Is that note appropriate and adequate in your opinion?

THE WITNESS: That note is the note that is required whenever the DME on an ILS does not come from a frequency pair co-located DME station, and, of course, that begs the comment I made earlier that we need ILS DME on all these facilities, but nobody did anything wrong on the day of the accident by not having it that way, but moving forward, yes, I think it's -- it's a note we should get rid of by putting in ILS DMEs.

CAPTAIN MISENCIK: Some of the criticisms that you've voiced or comments voiced about the -- the approach, do you feel that the TERPS procedures are applied uniformly in -- in approach development and charting?

THE WITNESS: It's moving in the right direction but probably not as well as it should. The answer is a qualified no, not as to fundamental safety or obstacle clearance. I think the FAA's people are very careful. They're not perfect in that regard, but I think they're diligent.

The -- when it was out in the fields, we feel in ALPA that they were less -- there were less standardization on areas of criteria that weren't used a lot, and, so, you would see some local variances, but the local flight inspection people and the procedures being designed in the field gave the procedure designer a better feeling for the procedures. So, that was the plus side.

Now we've moved it all to Oklahoma City, which is a down side on having people out in the field familiar in developing the procedures, but the plus side is we have the potential for real standardization, but it's not there yet.

The differences are usually areas of confusion and question marks rather than something that's egregious that's going to cause a pilot to have -- you know, not have obstacle clearance or run into a mountain. I don't mean those kinds of problems.

CAPTAIN MISENCIK: Are there any modifications or changes you'd like to see made in the way approaches are designed and approved and flown?

THE WITNESS: We would like to see the serious users of the system have a more formal input into the criteria and into the daily design of the procedures. We believe the -- not only do certain segments of the procedures staff need to be pilots, they need to be pilots that have heavy aircraft experience, C-141 types from the Air Force that are airline pilots, and my ideal would be to have a selected number of active airline pilots trained in TERPS and assigned for a tour of duty along with their flying duties to do some oversight with -- with some teeth in it over at the FAA by the -- in this area.

By the same token, the FAA people should have some of their people trained as second command on some of our major airlines that can go fly the jumpseat with that training and knowledge when the weather's really bad and see what we're up against out there flying when the going's real rough.

So, yeah, there's some areas in there where we could all be communicating on a technical level a lot better.

CAPTAIN MISENCIK: Do you feel that user input is solicited enough or there's enough user input taken into consideration in chart development?

THE WITNESS: Not on an effective level. The FAA, like Mr. Henderson said, they definitely coordinate with a designated representative from each user group, but what you get -- and I receive these forms for the Western U.S., which is Mr. Henderson's area. So, he and I have dealt with each other quite a bit the last three years or so, and the FAA's been very accommodating to me in providing additional forms to help me assess these procedures, but I've been looking at these forms for 25 years, and even then, I still don't see the same thing as I would if I had that approach chart in front of me to evaluate what was in the formulation stage.

So, I think that with the average user group, let's say of somebody's that done TERPS for 25 years like I have, they just really are not looking at these things. The FAA sends them out. There's no doubt about it, but I just -- with some rare exceptions where people have local knowledge, they just can't look at the thing in that form and get much out of it.

CAPTAIN MISENCIK: So, essentially, what are you advocating, that user input continues after -- even after the chart is certified then?

THE WITNESS: Well, the FAA will always listen to users after the fact. The door never closes completely, but it becomes a lot more difficult for everybody at that time, and it's not even fair to the FAA that somebody comes in, you know, three months after the thing's out and say, hey, look at this.

Whenever I brought up anything serious, like Mr. Henderson's always been very responsive. We don't always agree on how serious it is, but I think we agree most of the time.

But it would save a lot if the user saw it in a nice chart form and could get in there during the comment period so the FAA can keep the ball rolling where most of the time they should be able to keep it rolling.

CAPTAIN MISENCIK: As an airline pilot, what are your recommendations regarding the constant descent? We've heard input from various people here, also Captain Woodburn. How do you feel about the constant descent and also the monitored approach techniques?

THE WITNESS: Well, let me take the monitored approach first because that came into being on my airline while I was there as it did most airlines after a series of accidents, I think, in the late '70s or the early '80s. TWA's flight operations management decided it was a good idea to let the -- basically when the weather is really crummy, to have the co-pilot fly the approach preferably with the autopilot, so the captain was freed up to be a monitor and take over at minimums, and I can guarantee I tried it that way. It took awhile to get used to it, but it was a lot better.

But it requires that your co-pilot be a very strong aviator, too, and during a period of rapid expansion when some of the co-pilots were new, then sometimes there's a little kink in that system, but, conceptually, it's very sound.

As to constant rate descents, as a TERPS -- as a pilot, I'm all for them. As a TERPS guy, I just have to issue some caveats because often where we have our most difficult non-precision approaches, and this is not true of Guam, there's places a lot worse than Guam, the terrain along the intermediate and final approach segments, we have so much terrain, we can't even put an ILS in. It won't even work because I have to -- I misunderstood -- either misunderstood Mr. Henderson or -- that an ILS has much more obstacle clearance than a non-precision approach until you get to about a mile and a half off the end of the runway.

The typical outer mark of the ILS has 6 or 7-800 feet of obstacle clearance, particularly with the new MLS criteria that's taking over. Well, with a non-precision, you only need 250 feet with additives for precipitous terrain, if necessary. So, -- plus, you can make them steeper because they can go up to 3.77 degrees.

So, we end up, we've got non-precision approaches that are pretty steep in some locations, and if we start flying a constant descent like Mr. Terpstra mentioned, clear all those step-down fixes, we end up with four-degree glide scopes in some locations, and we have one more problem, is that we have non-precision approaches that are lined up straight in for a runway, but they have no straight-in minimums because the descent gradient exceeds TERPS for non-precision.

So, if a pilot lands straight in on one of those, he may be doing a six-degree slope in, and I'm not sure we're advising pilots enough about those kinds of traps.

CAPTAIN MISENCIK: Captain Roberts, for my final question, do you have any other thoughts concerning TERPS or the procedures that you would care to share with us or any thoughts that we may look at concerning this Guam accident?

THE WITNESS: Well, I think that -- that I would continue -- I can't emphasize enough how important co-located frequency paired DME is because now the air carriers all have the equipment. They show up in the localizers on both sides. The DME's there, and now we can use this DME for a lot of things, even when the ILS is working, and we haven't used that tool to its fullest.

These marker beacons are 1930s technology. The FAA wants to get rid of them. They're expensive to maintain. The little markers are already being decommissioned. The outer markers will probably disappear, but with DME, we have a running fix that can be -- that can mark the glide scope intercept point, so we can have a reasonableness test of the accuracy of the glide scope, and we can have a fix mark the decision height point. We have all this flexibility, but this will only work if it's frequency paired because the splitting of the sets just drives airline crews up the wall.

I think if nothing else comes out of this, I would urge the Board to recommend that the frequency paired DMEs be put on every FAA ILS that doesn't have them.

CAPTAIN MISENCIK: Thank you, Captain Roberts. No questions.

CHAIRMAN FRANCIS: KCAB?

MR. LEE: Thank you, Mr. Chairman. We have no questions. Thank you.

CHAIRMAN FRANCIS: FAA?

MR. DONNER: Yes, thank you, Mr. Chairman. Captain Roberts, thank you for that testimony. I enjoyed that.

I have two questions for you, sir, and the first is do you think that the FAA should require pilots to fly a minimum number of non-precision approaches annually?

THE WITNESS: I'm sorry. Would you repeat that?

MR. DONNER: Do you think, sir, that the FAA should require pilots to fly a minimum number of non-precision approaches?

THE WITNESS: There could probably be more done in the simulators. If they don't have an actual score out on the line, it might not be a bad idea, and with some real-world diversions and thrown them in and just, you know, give them some time to brief on it, and then do it in a training and not a punitive checking environment, it would be very beneficial.

MR. DONNER: Very good. One last question. In your statement in Exhibit 2 Victor, and you don't have to refer to it, it says, "The FAA should employ persons familiar with real-world airline operations, such as former airline pilots."

I just wondered if you were available should we have a vacancy.

THE WITNESS: Not -- not unless it's within 30 miles of San Clemente, California, no.

MR. DONNER: I don't think Oklahoma City's quite that close.

THE WITNESS: No, not quite, no. If it were near where I lived, I certainly would consider it on a consulting basis, but the FAA has its ways, and it takes a long time to get to certain things, and I would presume there's other people that may be in airline fields, and they're out on the street at age 45 or something that sure would like to see some of those people working in those jobs.

MR. DONNER: Thank you very much, sir. No further questions.

CHAIRMAN FRANCIS: Government of Guam?

MR. DERVISH: Thank you. No questions.

CHAIRMAN FRANCIS: NATCA?

MR. MOTE: Thank you, Mr. Chairman. No questions.

CHAIRMAN FRANCIS: Korean Air?

CAPTAIN KIM: No questions. Thank you.

CHAIRMAN FRANCIS: Boeing Company?

MR. DARCEY: No questions.

CHAIRMAN FRANCIS: Barton?

MR. EDWARD MONTGOMERY: No questions.

CHAIRMAN FRANCIS: Mr. Feith?

MR. FEITH: Just a couple. I just want to make sure that for the record, we're clear. In your statement that you had provided, Captain Roberts, in 2 Victor, let me just read you what you had written. I just want to make sure that we have covered all the points and all your concerns.

You made the statement in the second paragraph, "Our assessment shows that the FAA's published procedures for Guam International Airport and the resulting approach plate are seriously flawed. The procedures do not comply with the agency's own standards."

And I had heard you earlier saying that it met all the criteria, all the TERPS criteria. Is there something else that this doesn't meet that you haven't already talked about?

THE WITNESS: The -- the area that -- Number 1, I didn't write that statement, although I certainly read it and agreed with it. I think the general impression I have to say in all candor, if I showed up that night and not familiar with Guam and with those notes and that VOR step-down without local knowledge, I would have requested a VOR to DME Runway 6 left approach.

I just did not feel comfortable with this procedure, and I mentioned the fact, and only today did it finally sink into me that technically, technically 1440 did not have to be a minimum on this chart. When we wrote that, I felt it did, and I have looked at it a lot, and if I have that kind of problem, we have a problem. The system has a problem.

MR. FEITH: And one last question. We heard testimony today from Captain Woodburn about mandatory go-around of 500 feet. What's your opinion on that?

THE WITNESS: Well, that was the call-out on TWA. So, obviously I did it for most of my crew. I don't think they had it maybe the first few years I was there. Absolutely agree with it completely. In fact, I agree with his idea. I think there should be a thousand-foot call, a 500-foot call, and a hundred-foot call.

I think that that really helps crews on their awareness as to this critical, critical phase of flight, particularly in low-visibility conditions and non-precision approaches.

MR. FEITH: Very good. Thank you very much for your testimony.

THE WITNESS: Yes, sir.

CHAIRMAN FRANCIS: Mr. Berman for a point of clarification.

MR. BERMAN: Sir, when you refer to the 500-foot procedure, are you referring to a call-out or a mandatory go-around that's above the minimums?

THE WITNESS: I'm referring to call-out. In some better non-precision approaches, our MDA may have a height above touchdown well below 500 feet. This would just be a call for stabilization.

MR. BERMAN: Okay. Thank you. I understand.

CHAIRMAN FRANCIS: I think I have the last question, and this is a -- this is a question that I asked to Mr. Henderson, and I think you were here, on the co-located DME issue.

THE WITNESS: Yes, sir.

CHAIRMAN FRANCIS: And the feasibility of having a co-located DME in Guam, realizing that you have a powerful VOR DME, which is essential for en route navigation and the -- and the difficulties or non-difficulties of having the two DMEs.

THE WITNESS: There's no difficulty at all, except for dollars. That VOR DME is there to service a huge oceanic area, and it's really not even appropriate to the ILS as far as I'm concerned and should be as far removed from it as possible, and the ILS -- use the VOR DME to get on to the approach, fine, but we have many approaches where the arc initial approach segment south of VOR DME, but the ILS has its own DME, and when we switch over to the ILS, we're using the ILS DME. That's very common in this country.

CHAIRMAN FRANCIS: Thank you very much, sir, and I appreciate your -- your comments particularly about more all-around communication between those that are -- have different perspectives on trying to accomplish the same thing which is safer approaches.

Thank you.

THE WITNESS: Thank you.

(Whereupon, the witness was excused.)

CHAIRMAN FRANCIS: That concludes our hearing here. I'm not going to read this statement. It's going into the record, but let me say that we remain open to new and pertinent information whenever it may come in.

We reserve the right to reopen this hearing should we feel that that's warranted. We would encourage people to send, particularly the parties, the accredited representative, any further information to us, to the Board, in Washington, to Mr. Feith, and there will be at some point a deadline on that, but he or Mr. Schleede will -- will let you know when that is.

The -- everything that's been developed here will be coupled with that which is gathered at the other elements of this investigative process and will be considered in the preparation of the final report and ultimately the Board meeting to determine cause and to make recommendations.

I'd like to thank a whole lot of people here. I guess I'll start with the parties and the accredited representative. These are never easy times that we're going through after a major accident like this, and whether it's the on-site investigation or the continuing investigation or the hearing or that which comes on subsequently, it's very, very difficult, and I think that -- that we all appreciate, we at the NTSB, all appreciate the cooperative and forthcoming attitude on the part of -- of the parties here.

As you know, the way we run our investigations, we are -- we are enormously dependent on the parties in terms of generation of the evidence in the factual part of these -- of these investigations. So, our thanks to all of you and for being here and for helping us.

I'd also like to thank some folks from the NTSB without whom, in addition to those here present ad up here who do some of the work for part of the time, but Carolyn Dargan and Candy and Teddy and Van and Elaine and Ann are the folks who have worked long and hard to set this all up and to make sure that we have been able to keep rolling through these three days. So, I'm not sure that all of us ever truly appreciate what these folks do, but -- but certainly our -- our warmest thanks to these people.

The interpreters, thank you. The fact that we, for the -- for the Korean interpretation yesterday on the very technical sessions, ended up relying on somebody who spoke three languages rather than just two, it really was a problem of some -- finding someone who spoke not just Korean and English but also aviation, and certainly no reflection on you, and we appreciate all you did.

To our court reporter, thank you. We created a couple problems for you at the beginning, but we all seem to have gotten through.

Convention center staff, this is a brand-new facility. We're, I think, the first occupants, and they certainly couldn't have been more helpful for us.

The Honolulu Police Department has been enormously helpful, and I'd like in that context to -- to -- to thank our temporary employee, John O'Brien, who has come here to help us with security liaison. He's been a pleasure to work with and enormously helpful for us. Hopefully I haven't forgotten anyone.

Let me make a comment about the families. We started with the families, and I think it's appropriate to end with the families.

I can imagine or try to imagine the difficulty that you encountered in trying to follow what is enormously technical and complex. I would -- I would hope that if any of us can continue to be helpful to you in understanding what we're doing and what's going on, that you will -- that you will let us know.

As I mentioned on the first day, we are going to make a concerted effort to -- to ensure that we are in good and constant touch with you and can be responsive to -- to your needs.

We appreciate very much your being here, your interest. This is very much being done, as you know, to -- to ensure that this kind of a thing does not happen again, and -- and your support and your interest is -- is very, very important and very much appreciated by us. So, thank you very much.

Lastly, Mr. Schleede and Mr. Feith will be hosting a meeting immediately after this in Room 301 for the parties and the accredited representative, and I think if anyone else can think of something that I've forgotten? No?

We are then concluded here, and thank you all for being here and enjoy the rest of your time in Hawaii.

(Whereupon, the meeting was concluded.)